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The Hawaiian Monk Seal in the Northwestern Hawaiian Islands, 2001

Compiled and Edited by

Thea C. Johanos
and
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Pacific Islands Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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EXECUTIVE SUMMARY

In 2001, field studies of the endangered Hawaiian monk seal (*Monachus schauinslandi*) were conducted at all of its main reproductive sites in the Northwestern Hawaiian Islands. These studies provide information necessary to identify and mitigate factors impeding the species recovery by evaluating (1) the status and trends of monk seal subpopulations; (2) natural history traits such as survival, reproduction, growth, behavior, and feeding habits; and (3) the success of various activities designed to facilitate population growth.

Results of these studies are best described on a site-by-site basis, and the information presented in this document is organized accordingly. Site-specific data pooled for all sites, however, provide useful indices of the status and trends of the species as a whole, including the total number of pups at all main reproductive sites, the total of the site-specific mean beach counts, and the size composition of the seals observed during the counts (Fig. 1).

Since 1983, the number of pups born at the main reproductive sites has been highly variable, and the variability has been largely determined by the number born at French Frigate Shoals (FFS) (Fig. 1a), the largest subpopulation. In 2001, 178 pups were counted at these sites, 63 of which were born at FFS. Mean beach counts, excluding pups, from the main reproductive sites totaled 351.8 seals. Counts remained essentially unchanged from 1993 to 2000, but declined in 2001 (Fig. 1b).

From the mid-1980s to the mid-1990s, adults and pups comprised a growing portion of the animals counted while juveniles and subadults declined (Fig. 1c) and in 2001, the composition of the counts again was dominated by adults and pups. This composition bodes poorly for reproduction in the near future if older adult females are not replaced by young females reaching reproductive age. High mortality of immature seals appears to have led to the shift in composition, particularly at FFS.

Under provisions of the Marine Mammal Protection Act of 1972, the Working Group on Marine Mammal Unusual Mortality Events (UME) determined that a UME involving juvenile Hawaiian monk seals had occurred at Laysan Island in the spring of 2001. Declaration of the UME was based primarily on the deaths of 4 juvenile seals that occurred over a 1-week period on Laysan Island, but investigation of the UME included other major subpopulations to assess possible range-wide impacts. Objectives of the UME response team were to necropsy dead seals, visually evaluate the health of seals observed, and sample clinically abnormal and clinically normal seals from the 1- and 2-year-old cohorts (Yochem et al., 2003).

During 2001, four management activities were conducted by the Marine Mammal Research Program (Pacific Islands Fisheries Science Center, National Marine Fisheries Service) and cooperating scientists to enhance recovery of the species. First, debris

capable of entangling seals was removed from all study sites, and 8 seals were disentangled by field biologists. Second, researchers monitored beaches on Midway Atoll for disturbance and sought to mitigate human impacts through education. Third, researchers translocated weaned pups between islets within FFS to decrease their risk of shark predation. And fourth, 5 Galapagos sharks were removed after exhibiting predatory behavior toward monk seal pups at FFS.

This document describes these and other field studies conducted during 2001 and provides complete, standardized, and timely summaries of the research activities and findings at each study site. The ready availability of such information is essential for ongoing efforts to stop the decline of this species and enhance its recovery.

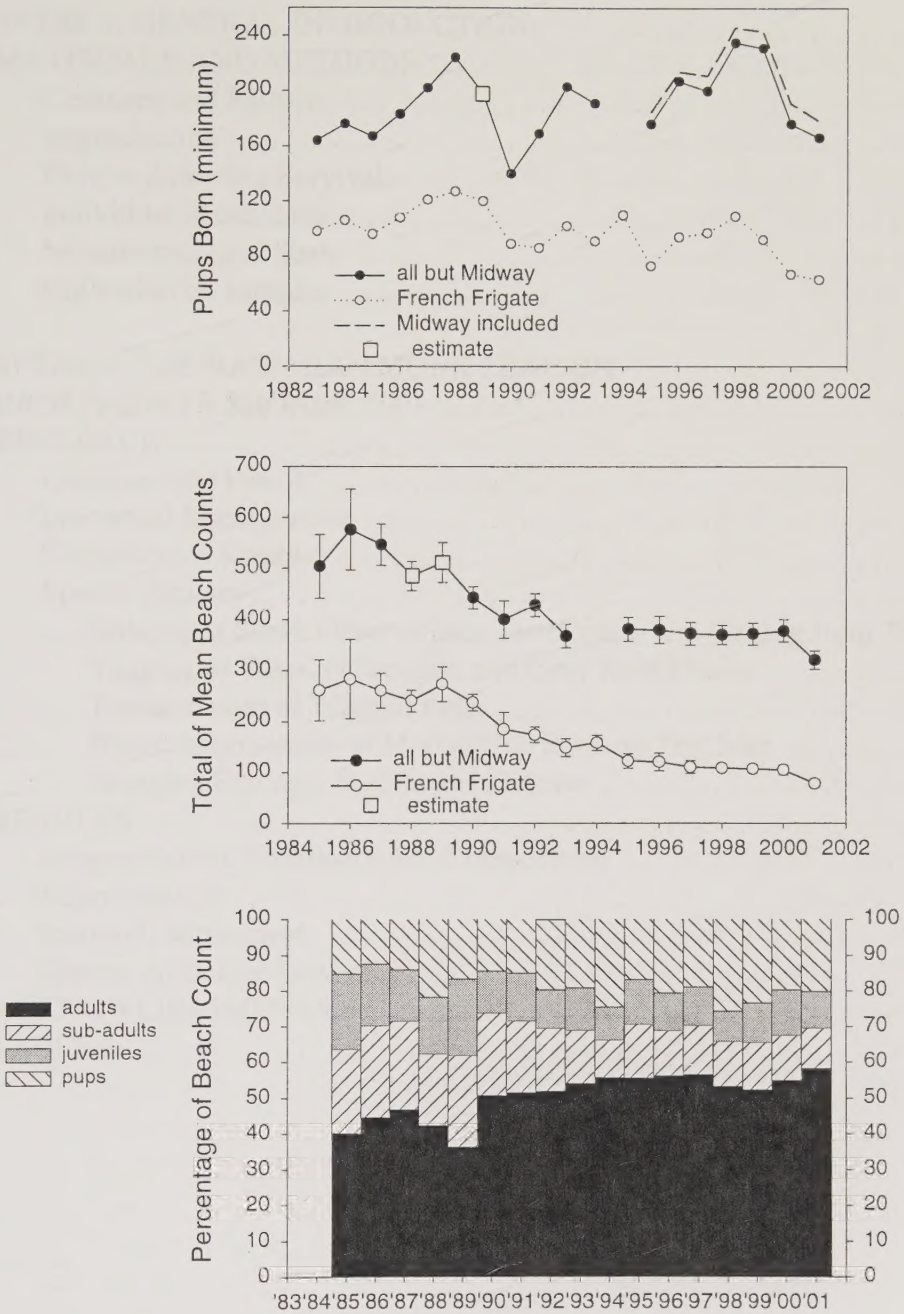
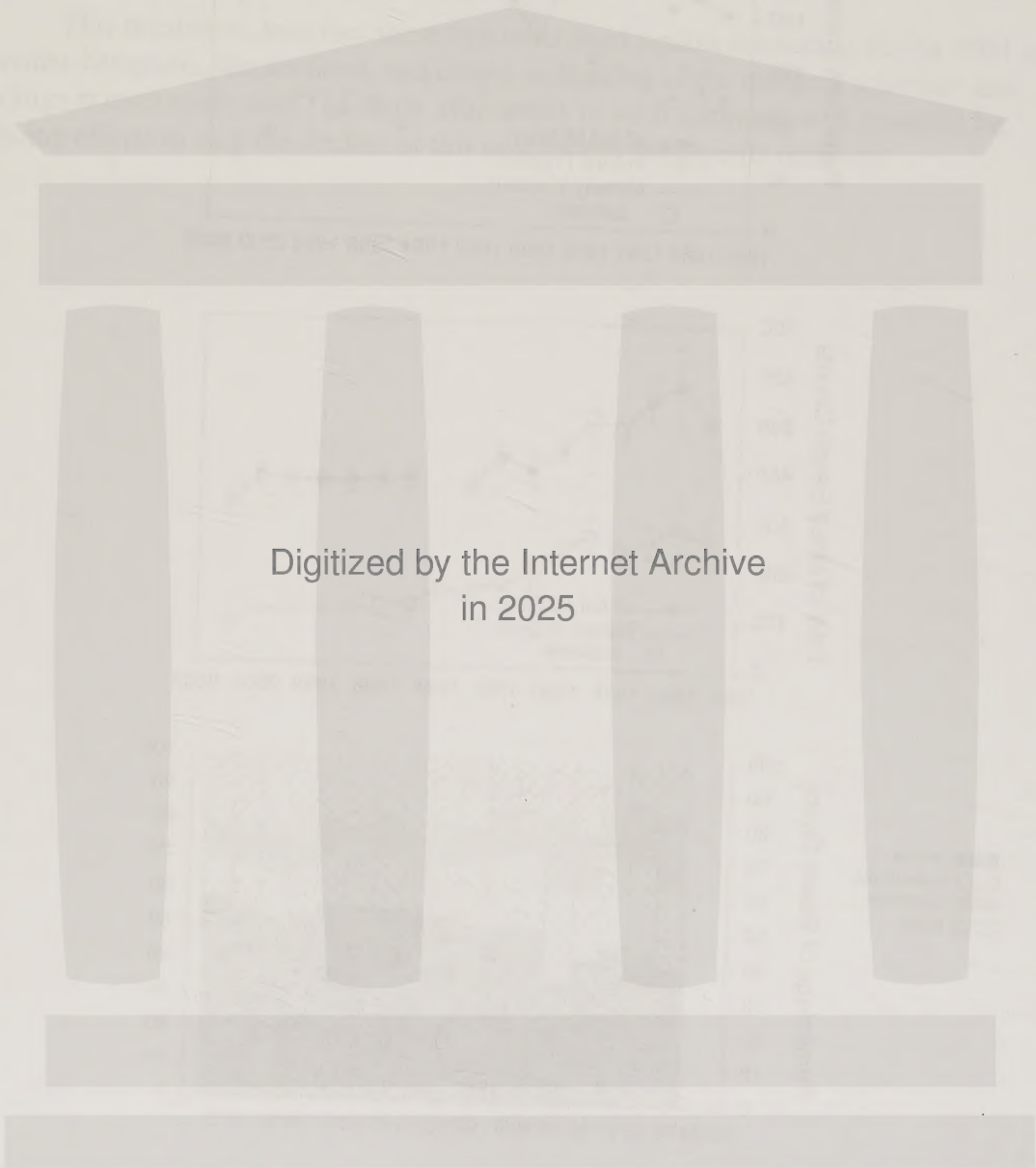


Fig. 1. Demographic trends of the Hawaiian monk seal, based on the main reproductive sites (excluding Midway Atoll). A) Number of pups born (minimum). B) Total of mean beach counts, excluding pups, with 1 standard deviation. C) Percentage of counts comprised of adults, subadults, juveniles, and pups.



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CHAPTER 1. GENERAL INTRODUCTION

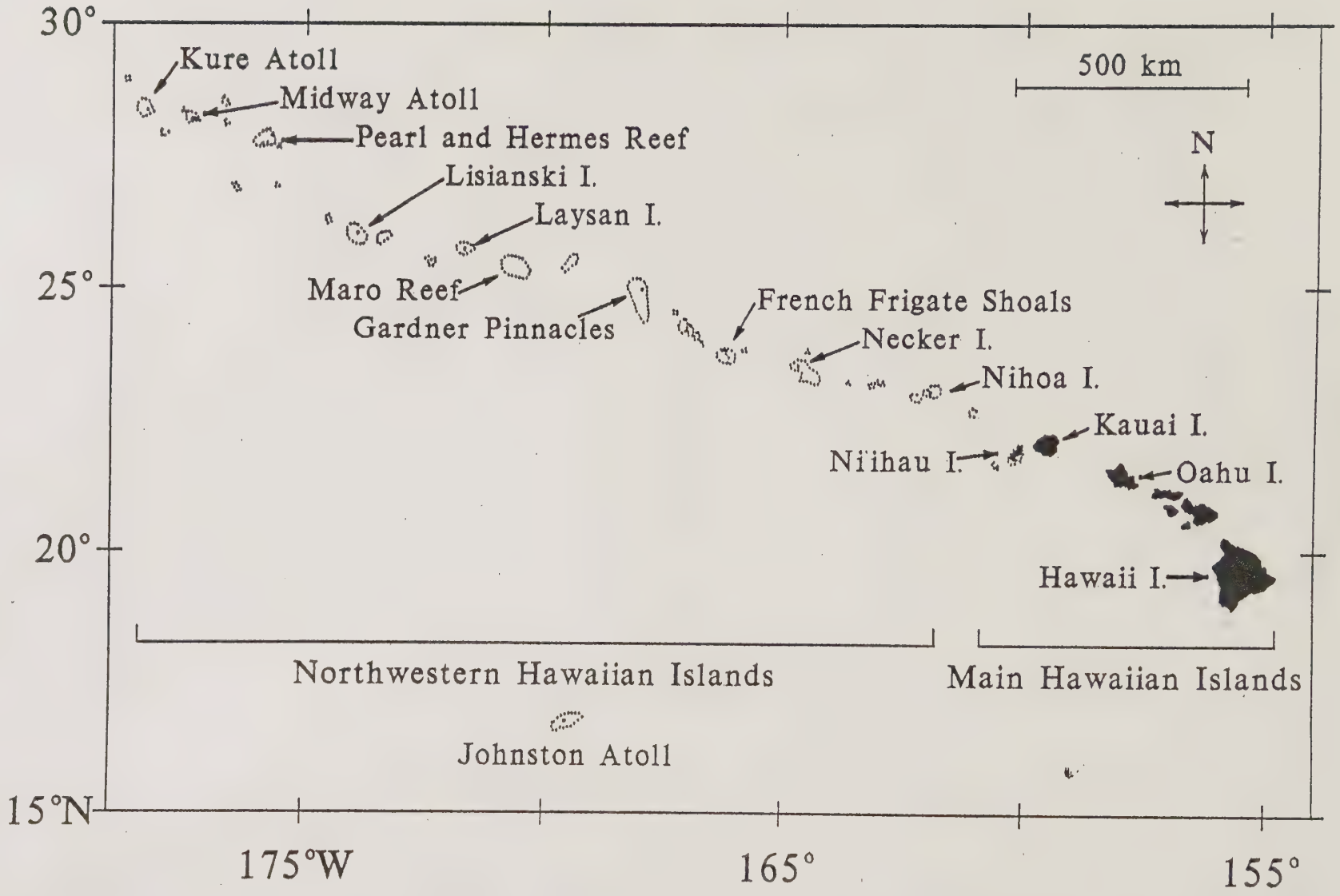

Fig. 1.1 The Hawaiian Archipelago.

The endangered Hawaiian monk seal (*Monachus schauinslandi*) hauls out and breeds in the Northwestern Hawaiian Islands (NWHI, Fig. 1.1). The National Marine Fisheries Service (NMFS) is the lead agency responsible for the recovery of the Hawaiian monk seal. Each year the NMFS Pacific Islands Fisheries Science Center, Marine Mammal Research Program conducts studies at the main breeding sites to provide information necessary to evaluate (1) the status and trends of the monk seal subpopulations; (2) natural history traits such as survival, reproduction, growth, behavior, and feeding habits; and (3) the success of various activities designed to facilitate population growth.

The Marine Mammal Research Program began research on Hawaiian monk seals at most major reproductive sites in the NWHI during 1980 (Lisianski Island), 1981 (Laysan Island and Kure Atoll), 1982 (French Frigate Shoals (FFS) and Pearl and Hermes Reef), and 1983 (Midway Atoll). Nearly every year thereafter, field camps of several days to 9 months were established to monitor and enhance the recovery of this species. Limited population monitoring has also been conducted at Nihoa and Necker Islands, where subpopulations may be limited to a small number of animals by availability of haulout area. Reports summarizing past NMFS research are listed in Appendix A.

During 2001, Hawaiian monk seal research activities included (1) conducting beach counts (censuses); (2) tagging weaned pups and other seals for permanent identification and retagging animals to maintain identification; (3) identifying other seals by previously applied tags and by natural or applied markings; (4) monitoring reproduction, survival, injuries, entanglements, interatoll movements, disappearances, and deaths; (5) performing necropsies; (6) collecting scat and spew samples for food habits analysis; (7) collecting skin punches and shed molt samples for a DNA tissue bank; (8) collecting samples of placentas found with or from "aborted fetuses" or with deceased perinatal pups for histological and bacteriological examination; (9) applying satellite-linked dive recorders to track animals at sea and to investigate diving behavior; (10) screening health and collecting blubber biopsies for fatty acid analysis; (11) disentangling seals; (12) inventorying and removing debris capable of entangling seals; and (13) investigating the Unusual Mortality Event at Laysan Island and other major subpopulations. Location-specific objectives and summaries of data collected during the 2001 field season are described in the following chapters. Much of the information presented in this memorandum is incorporated into larger data sets for additional analysis and publication elsewhere. Research was conducted under the authority of the following permits: State of Hawaii Entry Permit SEPO 100102, USFWS Special Use Permit HWN-01005, and NMFS Marine Mammal Permit 848-1335.

MATERIALS AND METHODS

Censuses and Patrols

The primary means of data collection were censuses and patrols. Censuses consisted of timed standardized beach counts during which an entire island or atoll was surveyed for seals on foot. Although data were collected on all seals, animals that were in the water or dead were excluded from the beach count totals. Identified individuals were counted only once if they were resighted during the survey. The resulting counts did not reflect total subpopulation size but provided an index of subpopulation size for comparison among years and locations. Data collected on each seal observed during censuses included size class (ranging from pup, juvenile, subadult, and adult size as described in Stone, 1984 and Appendix B); sex; location on the island; beach position (indicating whether the seal was in the water or on land); body condition (a subjective estimate; e.g., fat, medium, or thin); identification information (permanent or temporary identification numbers and tag numbers); molting status (an estimate of the percentage completed); and disturbance index (the extent that the observer disturbed the seal). Further data were collected if any of the following events occurred: (1) factors affecting survival (e.g., entanglements, mobbings, or shark injuries), (2) animal handling, (3) photography, and (4) documentation of tag condition (e.g., good or broken). In addition, behavioral data (seal associations and interactions) were collected on Laysan and Lisianski Islands. A sample census form and guidelines for its completion are included in Appendix B. Censuses were conducted once at Nihoa Island, three times at Necker Island, twice at Gardner Pinnacles, and every 4 to 7 days at all other locations, starting at 1300 Hawaii Standard Time when possible, using census methods and criteria outlined in Johanos et al. (1987). Atoll-wide counts for locations with more than a single island (French Frigate Shoals, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll) were completed within 2 days. The perimeter of each study area was divided into sectors to facilitate the analysis of data and detection of demographic trends in different geographic areas. Census methods specific to each location are detailed in the following chapters.

Patrols consisted of untimed surveys of an entire island perimeter on foot. Information collected during patrols was similar to that collected during censuses. Because patrols were not timed, observers concentrated on documenting adult and subadult behavior, identifying and marking individuals, and collecting scat and spew samples. Island-specific standardized patrols were conducted at some locations and are described in the following chapters.

During all observation periods (i.e., censuses, patrols, and incidental sightings), observers attempted to minimize seal disturbance by walking above the beach crest and using vegetation as a visual barrier. On census days, activities that could disturb the animals and bias the count were not conducted until after the count was completed. Additionally, the following were recorded whenever observed: (1) births, pup exchanges, and weanings; (2) mating activities, adult male aggression, and post-mobbing

aggregations (defined below); (3) entanglements in marine debris; (4) injuries; and (5) deaths.

Reproduction

Parturient females were identified when possible, and birth and weaning information was recorded. Because parturient females often nurse pups other than their own (Boness, 1990; Boness et al., 1998), efforts were made to identify pups and document changes in nursing relationships from birth to weaning. A pup exchange occurred when the pups of 2 lactating females were switched or one nursing female suckled multiple pups. Typically, such exchanges occur during an aggressive interaction between the 2 females. On other occasions, a mother and pup may become separated, and 1 or both seals will then actively seek and obtain another nursing relationship (Boness, 1990).

The average nursing period was calculated for some or all pups at each location. The average lactation period of parturient females was also calculated at FFS because higher subpopulation density and frequent pup exchanges (Boness, 1990; Boness et al., 1998) made it difficult to track individual pups and determine their nursing period. Nursing or lactation periods were defined as the number of days from birth until the end of the last nursing relationship. Temporary breaks (e.g., if a mother and pup became separated and 1 or both seals subsequently obtained another nursing relationship) were not subtracted from the total. When the exact birth or weaning date was not known, but occurred within a range of 4 days or less, then the midpoint of that range was used as the start or end date for calculation of average nursing or lactation period. Nursing or lactation data were not used if the birth or weaning range exceeded 4 days, or if the pup died or disappeared before weaning.

Factors Affecting Survival

The origins of a wide range of injuries were distinguished based upon characteristic wound patterns described in Hiruki et al. (1993). Injuries were documented if they were related to mounting, large shark, or entanglement or if they were considered severe enough to possibly affect survival. Injuries were considered severe and were summarized if they consisted of (1) 3 or more abscesses, each <8 cm in diameter, or 1 abscess with a diameter ≥8 cm; (2) an amputation of at least half a flipper (either foreflipper or hindflipper); (3) at least 3 punctures or gaping wounds, if largest dimension was <8 cm, or 1 gaping wound with a maximum diameter-largest dimension ≥8 cm; or (4) densely spaced (overlapping) scratches, abrasions, or lacerations covering an area equivalent to half the dorsum or evidence of extensive underlying tissue damage (e.g., an uneven or darkened surface of the injured area, leaching fluids), or if they impaired seal movement. Major healed injuries incurred since the previous season were documented but not included in summaries.

A seal was listed as dead if its death or carcass was observed. Deaths summarized here include carcasses found at the beginning of the field season if the seal had clearly

died during the calendar year. A seal was listed as probably dead if it sustained severe injuries or was emaciated (with skeletal structure clearly evident) and subsequently disappeared. In addition, one of the following conditions must have been satisfied to place a seal in the "probably dead" category: (1) the seal was lethargic, had difficulty moving, or floated listlessly in the water, and disappeared more than a week before the end of data collection; or (2) the seal was in a deteriorating condition (loss of weight, enlargement of abscesses, sloughing of skin) and disappeared a minimum of 10 surveys or 1 month before the end of data collection (whichever was longer). Nursing pups were listed as probably dead if they disappeared within 3 weeks of birth.

Multiple male aggression (or "mobbing") and other mating-related male aggression was observed and recorded. By definition, multiple male aggression occurred when more than 1 male attempted to mate with a single seal, usually an adult female or immature seal of either sex, causing injury or death of that seal (e.g., Alcorn, 1984). Single male aggression was defined as any incident when 1 adult or subadult male repeatedly bit the dorsum, attempted to mount, and tried to prevent the escape of another seal. These incidents were summarized in this report if they simultaneously involved more than 1 male aggressor or resulted in at least 1 puncture or gaping wound (missing skin or extending into the blubber layer) or $\geq$ 15 scratches to the dorsum or flanks. Post-aggression aggregations were also summarized; these were groups of males congregated on the beach, attending a seal with new mounting injuries as described above.

Individual Identification

During censuses and patrols, individual seals were identified with tags, applied bleach marks, scars, or natural markings. After weaning, pups were tagged on each hind-flipper with a colored plastic Temple Tag,®[1] uniquely coded to indicate island or atoll subpopulation, year of birth, and individual identification number (Gilmartin et al., 1986). In addition, a passive integrated transponder (PIT) tag was implanted subcutaneously in the posterior dorsum of most weaned pups (see Lombard et al., 1994, for detailed tagging procedures).

Colored plastic Temple Tags have been applied to nearly all weaned pups since 1981 at Kure Atoll, 1982 at Lisianski Island, 1983 at Laysan Island and Pearl and Hermes Reef, 1984 at French Frigate Shoals, and 1995 at Midway Atoll. Pups at Midway Atoll, Necker and Nihoa Islands, and the main Hawaiian Islands have been tagged opportunistically since 1983. Since 1991, PIT tags have also been implanted subcutaneously in the ankle (1991) or the dorsum (all subsequent years) of most weaned pups.

During 2001, untagged immature and adult seals were opportunistically tagged with Temple Tags uniquely coded to indicate that their ages and birth locations were

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[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

unknown. These seals also received PIT tags. Seals with lost or broken tags were retagged to maintain their identities.

Seals were bleach-marked for individual identification (Stone, 1984), using the solution described in Johanos et al. (1987). Molting seals were re-marked with bleach to maintain their identities until the next molt. Some nursing pups were also bleach-marked prior to the postnatal molt to facilitate identification during the nursing period.

Tags, scars, other natural markings, and any applied bleach marks were sketched by hand on a scar card for each seal, and this card was revised throughout the field season to maintain a current description of the identifying marks of each seal. Digital and film photographs of scars and natural markings were added to individual identification files begun during 1981 or 1982.

Subpopulation size and composition were estimated at locations where observers rarely encountered new unidentified seals during the latter part of the field season. These statistics included all individuals observed alive at the location from March through August and all known parturient females and pups born anytime during the year.

The movement of seals between island or atoll subpopulations within and between years complicates the estimation of subpopulation size and composition. This is particularly true at Midway Atoll, where a number of the observed seals were tagged at other locations (primarily Kure Atoll and Pearl and Hermes Reef). Therefore, standardized rules for assigning each identified seal to just one subpopulation are applied as follows: If a seal was observed at more than one location during March-August, it was included in the subpopulation where it was sighted nearest to May 15, unless it pupped or molted at another location. A parturient female was always included in the subpopulation where she pupped, and a nonparturient seal was included in the subpopulation where it molted. Pups were always included in the subpopulation where they were born.

Measurements of Seals

Pups were measured to provide information on condition and maternal provisioning. Measurements were taken as soon after weaning as possible, and measurements taken within 2 weeks after weaning were included in summaries. Measurements included straight dorsal length (Winchell, 1990) and axillary girth (American Society of Mammalogists, 1967). Older animals captured for foraging ecology, health, or disease studies were also measured.

Collection of Samples

Samples were collected for a DNA tissue bank, pathology analysis, investigation of food habits, and documentation of marine debris. Tissue punches for DNA were collected during tagging efforts for all newly tagged or retagged seals and during necropsies on seals that had died recently. Samples of placentas found with or from "aborted fetuses" or deceased perinatal pups were also collected.

For each dead seal recovered, an external examination was made, photographs were taken, and external measurements and observations were recorded. For a recent death, an internal examination was made, and samples of tissue, organs, parasites, and stomach contents were collected. Necropsy procedures and sample collection methods are adapted from Winchell (1990).

Scat and spew samples were collected opportunistically for analysis of food habits (Alcorn, 1984). These samples were collected from seals of known sizes and sex classes when possible.

Nets, lines, ropes, and other debris capable of entangling seals and turtles were documented and inventoried. From 1982 to 1998, potentially entangling marine debris was incinerated on site. Beginning in 1999, because of new Fish and Wildlife Service regulations, marine debris was not handled in this manner at most sites. At Kure Atoll, dangerous or entangling debris was destroyed by incineration, following the methods described in Johanos and Kam (1986). At all other locations, debris was cut into manageable-sized pieces and placed in storage bins or secured piles at centralized locations for subsequent removal by ship.

CHAPTER 2. THE HAWAIIAN MONK SEAL ON FRENCH FRIGATE SHOALS, 2001

Suzanne M. Canja, Brenda L. Becker, Allan D. Ligon, and Sean A. Hayes

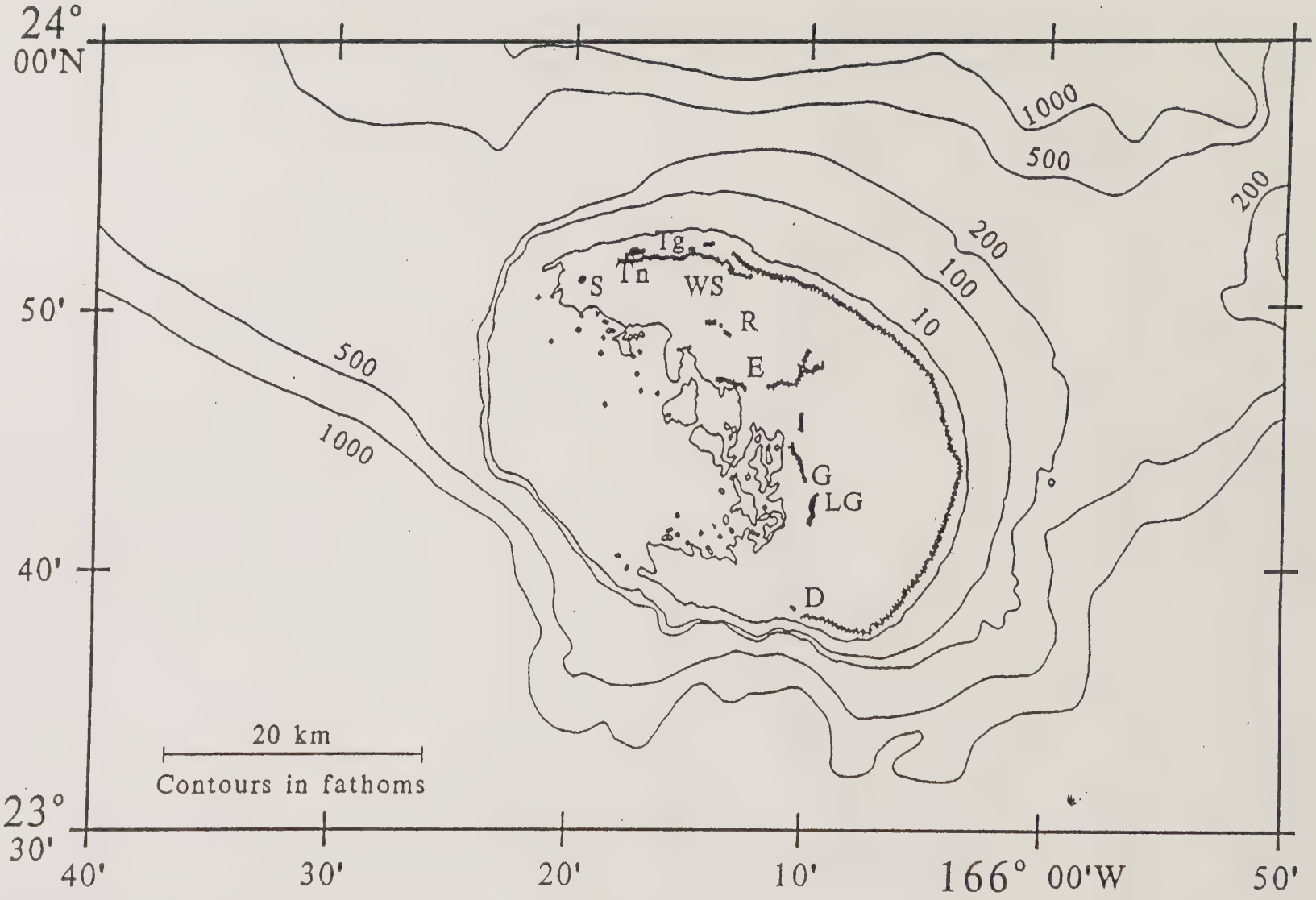

Fig. 2.1. French Frigate Shoals in the Northwestern Hawaiian Islands. Islands are: Disappearing (D), East (E), Gin (G), Little Gin (LG), Round (R), Shark (S), Tern (Tn), Trig (Tr), and Whaleskate (WS).

The largest subpopulation of Hawaiian monk seals is located at French Frigate Shoals (FFS, lat. 23°45'N, long. 166°10'W), ca. 830 km northwest of Oahu in the Northwestern Hawaiian Islands. This atoll is part of the Hawaiian Islands National Wildlife Refuge (Fig. 1.1) and consists of 9 permanent islets (Disappearing, East, Gin, Little Gin, La Perouse Pinnacles, Round, Shark, Tern, and Trig), 3 semipermanent islets (Bare, Mullet, and Whaleskate), and several transient sand spits (Fig. 2.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at FFS in 1982. During 2001, research was conducted by NMFS from March 8 to March 12 and May 13 to October 1. Incidental observations were recorded by U.S. Fish and Wildlife Service (USFWS) personnel during the rest of the year. The perimeters of the 5 larger islets (East, Gin, Little Gin, Tern, and Trig) were divided into sectors using artificial or natural landmarks. Research activities specific to this subpopulation in 2001 included (1) monitoring and removal of Galapagos sharks preying on monk seal pups at Trig Islet, (2) tagging of Galapagos and tiger sharks to determine movement patterns within the atoll, (3) translocation of newly weaned pups to reduce their risk of shark attack, (4) night observations of mom/pup pairs to determine their nocturnal aquatic activity and the potential for night shark attacks, (5) retagging or newly tagging seals, (6) investigation of juvenile foraging ecology using seal-mounted video cameras (CRITTERCAMS) and time-depth recorders (TDRs), (7) assessment of seal foraging using archival movement recorders imbedded in simulated benthic "rocks", (8) videographic surveys of benthic habitat, (9) collection of reef vertebrates and invertebrates for Hawaiian monk seal prey fatty acid analysis, and (10) removal of marine debris and assessment of accumulation rates within the lagoon.

Censuses and Patrols

Atoll-wide censuses (n = 17) were conducted every 7 d, on average, from May 29 to September 18. Each atoll census required 2 days to complete, and data collection began between 0855 and 1525 and ended between 1106 and 1830 Hawaii Standard Time. La Perouse Pinnacles were not routinely surveyed as there are no seal haulout sites available.

Individual islet censuses and patrols were scheduled to ensure that the entire atoll was monitored at least once each week during May 16-September 19. Frequency of surveys was higher at islets where most pups were born or at locations in close proximity to these islets (i.e., Bare and Mullet); thus, Trig was monitored on average every 1-3 days; Bare, East, Gin, Little Gin, Mullet, Round, and Tern averaged every 3-4 days; and Disappearing, Shark, and Whaleskate Islets averaged every 5-7 days. Whaleskate, Bare, and Mullet Islets were rarely above water during the sampling season.

Individual Identification

A total of 331 individuals (268 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Bleach marks were applied to 39 seals, including 16 nursing pups. Forty weaned pups were tagged with Temple Tags, 35 of which also received a passive integrated transponder (PIT) tag. Ten adult seals (7 males and 3 females) were tagged with Temple Tags and a PIT tag.

Collection of Samples

Eighty-four scat and 7 spew samples were collected. Skin punches were collected from 48 seals during tagging and a shed molt sample was collected from 1 seal. Tissue samples were collected from 6 necropsied seals and skeletal samples from 7 carcasses. In addition, 1 juvenile and 4 pup carcasses (1 fetus, and 2 late-term and 1 full-term abortions) were collected for necropsy. Three fresh placentas were collected. Health and disease samples were collected from 2 seals and a dead pilot whale. Forty-six dried ticks were collected to supplement health and disease investigations. In total, 78 items of potentially entangling debris were inventoried and stored for removal by ship.

Special Studies

Galapagos Shark Observations, Deterrence, and Culling from Trig Islet

From June 3 through September 6, Trig Islet was monitored daily for a total of 86 days (excluding nine weather/logistical days) to document the presence of Galapagos sharks and their predatory behavior towards monk seal pups. Five sharks that exhibited predatory behavior were removed; specimen samples were collected from 4 of these animals. One Galapagos shark that had recently been instrumented with an acoustic tag was recaptured and released. This shark had not exhibited predatory behavior but was caught incidental to other aggressive Galapagos in the area at the time. Two Galapagos shark attacks on nursing pups were observed, 1 of which was fatal.

Tagging of Tiger, Galapagos, and Gray Reef Sharks

During June and July, 13 sharks (3 tiger, 2 Galapagos, 8 gray reef) were captured, measured, and tagged around East or Trig Islets. Each shark received a highly visible identification tag in the dorsal fin, and Galapagos and tiger sharks were additionally instrumented with acoustic tags to monitor each shark's movement within the atoll. Movement of acoustic tagged sharks from the previous season (1 Galapagos and 7 tiger sharks) continued to be monitored. This project is part of a study initiated in 2000 and conducted by California State University Long Beach, Hawaii Institute of Marine Biology, and the NMFS Narragansett Laboratory.

Three additional sharks (1 gray reef, 1 whitetip, and 1 tiger shark) were tagged with colored, numbered Floy® spaghetti tags for future identification incidental to the study on Galapagos shark predation mitigation.

Translocation of Weaned Pups

Eighteen newly weaned pups were translocated, typically on the day of weaning, to other islets within the atoll with lower shark activity in efforts to decrease their risk of shark predation. All 17 newly weaned pups on Trig Islet were translocated; 8 pups to Little Gin, 6 pups to Gin, and 3 seriously shark-bitten pups to Tern Islet. In addition, a newly weaned pup with a fresh shark bite on Round Islet was translocated to Little Gin. One of the Trig-born pups who had been translocated to Little Gin was recaptured 2 months later on Trig with a fresh shark bite; it was then translocated to East Islet.

Night Observations of Mother/Pup Pairs on Trig Islet

During the evenings of June 23-24 and July 5-6, mother/pup pairs were monitored for 12 hours from sunset to sunrise to determine their nocturnal aquatic activity as it relates to shark predation risks. Half the pups present entered the water before daylight (10 of 20 focal group observations).

Foraging Ecology, Health, and Disease

In July and August, in collaboration with the National Geographic Society, a pilot study was conducted to investigate juvenile seal foraging ecology at FFS; 2 juveniles (1 male, 1 female) were instrumented with a CRITTERCAMS, TDR, and a VHF radio transmitter. The CRITTERCAMS were removed after 3 and 11 days. The VHF radio transmitters and TDRs were left on the seals an additional 4 and 14 days to investigate whether cameras might affect the seals' diving behavior. In addition, blood, fecal, bacteriological and virological samples, and blubber samples were collected from both seals to supplement health and disease investigations.

In August, archival movement recorders imbedded in simulated "rocks" were deployed in seal foraging sites to monitor year-round foraging activity. Videographic surveys were also conducted to map benthic habitat types. In addition, researchers also collected reef vertebrates and invertebrates for analysis of fatty acids in potential monk seal prey.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 17 atoll censuses was 113.1 seals (± 14.0) including pups and 87.4 seals (± 13.1) excluding pups (Table 2.1). Total seals identified as part of the spring-summer subpopulation were 325 individuals, 262 excluding pups (Table 2.2). This number

is a subset of the total identified in the calendar year and is an unknown proportion of the total subpopulation as many of the older, untagged seals could not be uniquely identified. The numbers of tagged known-age seals born at FFS during the period from 1984 to 2000, and resighted at any location in 2001, are summarized in Table 2.3.

Reproduction

At least 63 pups were born at FFS in 2001; 42 were successfully weaned, 2 were still nursing at the end of the camp, and 19 died or disappeared prior to weaning (Table 2.4a). Nursing periods and measurements of weaned pups are summarized in Table 2.4b. The mean (±SD) lactation period for 30 females was 35.2 d (±6.1 d). Twelve pup exchanges were documented between 14 adult females; 2 of these events were observed and another occurred when researchers intervened to improve the survival of a smaller nursing pup. Two births were observed, 1 of which was videotaped.

Interatoll Movement

Interatoll movement was documented for 3 seals that completed 3 movements between FFS and either Laysan or Necker Island (Tables 2.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, emaciation, and unknown factors resulted in 35 life-threatening conditions, which led to the confirmed deaths of 14 seals (including 8 perinatal deaths) and the probable death of 13 seals; 9 of which were nursing pups (Table 2.6). Seven of the nursing pup disappearances occurred at Trig, 1 at Gin, and 1 at Round Islet. Shark attack was the suspected cause for the disappearances for all of the nursing pups at Trig and Round Islets; as all of these pups appeared healthy and normal, and there were numerous observations of Galapagos sharks patrolling, attempting, and successfully attacking pups on Trig Islet. A high proportion of all the FFS live-born pups were attacked by sharks; excluding perinatal deaths, 20.4 % of the pups (11/54) were injured, including 7 moderately to severely injured pups (3 died) and 4 pups that received minor bites not summarized on Table 2.6.

No incidents of adult male aggression were observed; however, 2 seals received injuries characteristic of male mounting. No seals were entangled in marine debris. Three immature female seals (a weaned pup, juvenile, and subadult) were found behind the deteriorating seawall at Tern Island and were either removed or guided out uninjured by researchers. In addition to incidents summarized in Table 2.6, an adult female seal had a healed hindflipper amputation from a shark attack that had occurred since the previous field season, and an aborted fetus was found on Trig Islet in May.

ACKNOWLEDGMENTS

We acknowledge the support of the USFWS, Hawaiian Islands National Wildlife Refuge staff and volunteers, particularly Anthony Palermo for his gracious support and assistance with data collection, necropsies, and rescuing a seal stranded behind the seawall. Special thanks to Allison Veit and USFWS volunteer Sarah Ward for their assistance with a seal necropsy. Thanks to Dominique Horvarth for her cheerful logistical support, always there to help get our equipment and supplies out to Tern Islet. We also thank Kyler Abernathy, Dr. Robert Braun, Aaron Dietrich, Frank Parrish, John Peshon, and Brad Ryon for their assistance with translocation of newly weaned pups and other noteworthy seal observations on Trig Islet. We additionally thank Aaron Dietrich for documenting pupping on East Islet during turtle nesting studies. We thank the captain, officers, and crew of the NOAA ship *Townsend Cromwell* and the pilots of Pearl Pacific Enterprises for logistical assistance.

TABLES
for French Frigate Shoals

Table 2.1.--Summary statistics for atoll censuses ($n = 17$) of Hawaiian monk seals at French Frigate Shoals from May 29 to September 18, 2001.

Size/Sex	Mean number of individuals	Standard deviation
Adults	67.4	10.4
Male	20.5	4.1
Female	41.0	8.9
Unknown	5.8	4.2
Subadults	11.0	4.4
Male	4.3	2.2
Female	5.8	2.7
Unknown	0.9	0.9
Juveniles	8.9	2.9
Male	3.4	1.5
Female	5.1	2.1
Unknown	0.5	0.6
Pups	25.8	2.9
Male	13.2	3.0
Female	10.5	3.1
Unknown	2.0	2.2
Non-pup total	87.4	13.1
Grand total	113.1	14.0

Table 2.2.--Composition of the Hawaiian monk seal subpopulation at French Frigate Shoals during the spring and summer of 2001. These numbers are an unknown proportion of the entire subpopulation as many untagged adults could not be uniquely identified. All known parturient females and pups born during the calendar year are included.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	79[a]	119[a]	0	198[a]	0.7:1
Subadults	13	16	0	29	0.8:1
Juveniles	13	22	0	35	0.6:1
Pups	33[b]	27[c]	3[d]	63	1.2:1
Non-pup total	105[e]	157[e]	0	262[e]	0.7:1
Grand total	138[b,e]	184[c,e]	3[d]	325[e]	0.8:1

[a] These numbers are an unknown proportion of the entire adult subpopulation.
[b] Includes 5 perinatal pup deaths.
[c] Includes 2 perinatal pup deaths.
[d] Includes 2 perinatal pup deaths, excludes 1 fetus.
[e] These numbers are a minimum subpopulation estimate.

Table 2.3.--Summary of tagged known-age seals born at French Frigate Shoals and resighted at any location in 2001.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2001
1984	17	Male	49	9[a]
		Female	43	13[b]
1985	16	Male	48	3[a]
		Female	38	9[b]
1986	15	Male	52	7[a]
		Female	48	18[a,b]
1987	14	Male	55	7
		Female	51	8
1988	13	Male	52	4
		Female	62	5
1989	12	Male	51	7
		Female	50	7[b]
1990	11	Male	38	1
		Female	41	8[b]
1991	10	Male	24	1
		Female	44	4[b]
1992	9	Male	36	2
		Female	55	10[b]
1993	8	Male	40	2
		Female	39	2
1994	7	Male	47	1
		Female	48	7[b]
1995	6	Male	29	2
		Female	26	12[a]
1996	5	Male	39	3
		Female	30	3
1997	4	Male	32	1
		Female	19	0
1998	3	Male	49	7
		Female	39	9
1999	2	Male	30	7
		Female	30	6
2000	1	Male	27	7
		Female	30	17

[a] Cohort survivors include seals removed from French Frigate Shoals for rehabilitation that remain in permanent captivity (n = 14).

[b] Cohort survivors include seals removed from French Frigate Shoals for rehabilitation or direct translocation and released at Kure or Midway Atoll (n = 19).

Table 2.4a.--Summary of Hawaiian monk seals born at French Frigate Shoals in 2001.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	33	27	3[a]	63
Died/probably died at/or prior to weaning	10	6	3	19
Still nursing	1[b]	1[b]	0	2[b]
Weaned	22	20[b]	0	42
Tagged	21[c]	19[b,d]	0	40

[a] Excludes a fetus.
[b] Although 3 pups (a male and 2 females) were still nursing at the end of the NMFS field camp, 1 of the female pups was confirmed weaned and was tagged in June 2002.
[c] One pup was severely injured by a shark, precluding safe restraint, and disappeared shortly after the injury healed in July.
[d] A pup born and weaned after the NMFS camp was tagged in December by USFWS. One newly weaned pup died shortly after receiving a severe shark bite and was not tagged.

Table 2.4b.--Summary of nursing periods and measurements of weaned pups at French Frigate Shoals in 2001. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	36.2	105.2	124.8
St. dev.	5.1	10.0	6.6
n	19	38	38

Table 2.5a.–Documented movement of Hawaiian monk seals to French Frigate Shoals from other locations in 2001, summarized by movements between 2 locations. No seals made more than 1 trip.

Original location	Number of trips, size, and sex class
Laysan Island	1 adult male
Necker Island	1 adult female

Table 2.5b.–Documented movement of Hawaiian monk seals from French Frigate Shoals to other locations in 2001, summarized by movements between 2 locations. No seals made more than 1 trip.

Destination	Number of trips, size, and sex class
Laysan Island	1 adult female

Table 2.6.--Factors affecting Hawaiian monk seal survival at French Frigate Shoals in 2001.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
Adult	Female	1	1	0	0
Weaned pup	Male	1	1	0	0
	Female	2	1	1	0
Nursing pup	Male	4	2	2[a]	0
Mounting by Males					
Adult	Female	1	1	0	0
Subadult/Adult	Unknown	1	0	0	1
Entanglement					
(none observed)					
Emaciation					
Adult	Male	1	0	1[b]	0
Juvenile	Male	2	0	0	2
	Female	2	0	1[c]	1[b]
Unknown					
Adult	Male	1	1	0	0
	Female	1	1	0	
Juvenile	Female	1	0	1	0
Nursing pup	Male	8	0	5[d]	3
	Female	6	0	2[d]	4
	Unknown	3	0	1[e]	2[f]

[a] The fatal attack of 1 pup by a Galapagos shark was observed.

[b] The seal was in poor condition and had sustained a fresh shark injury just prior to death/disappearance.

[c] The seal sustained a blunt/trauma blow to the head prior to death.

[d] All were perinatal deaths; none of the pups were seen alive.

[e] Bones from the flattened carcass were the size of a nursing pup.

[f] Only a fresh placenta was found; no mother or carcass observed.

CHAPTER 3. THE HAWAIIAN MONK SEAL ON LAYSAN ISLAND, 2001

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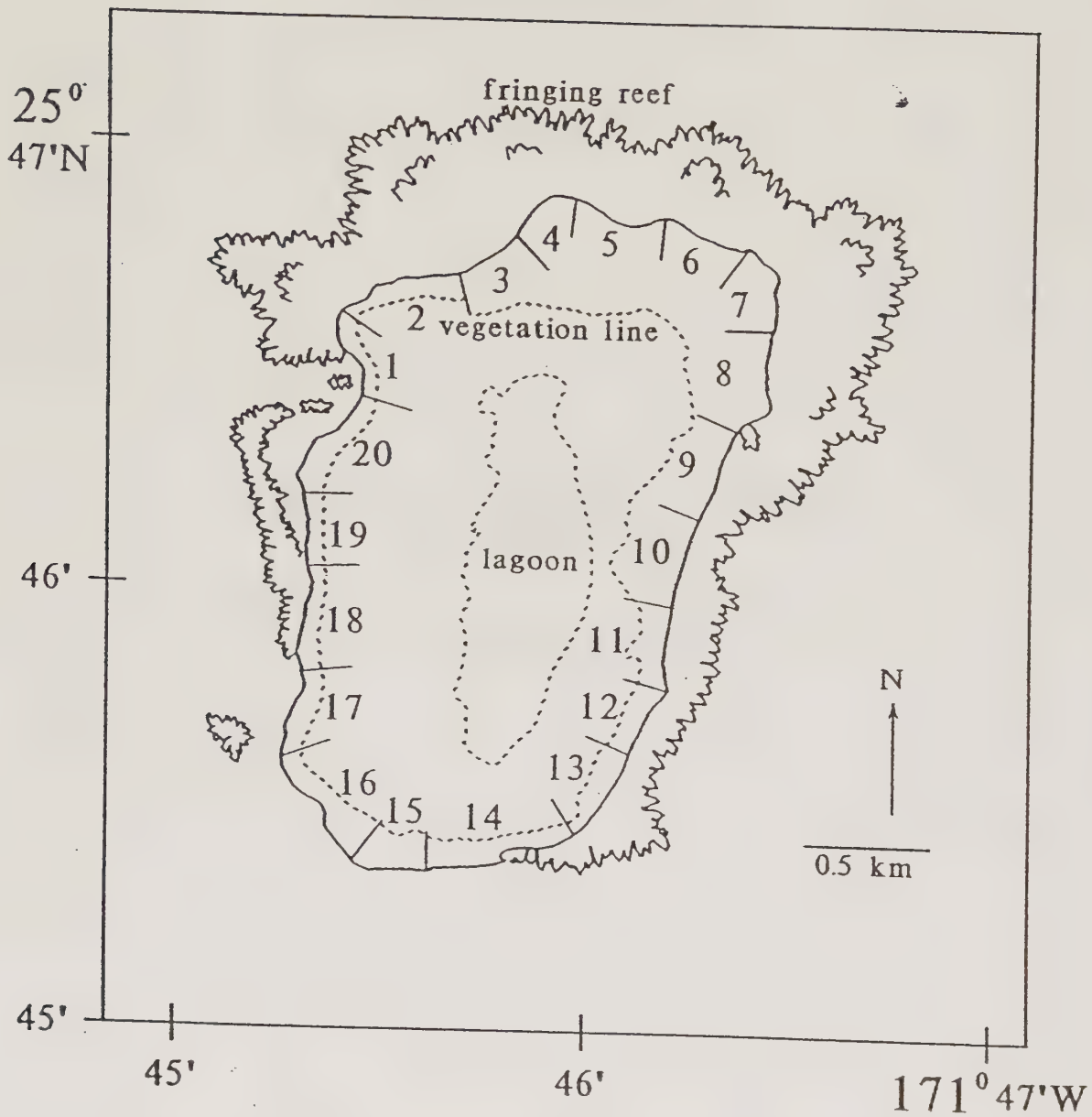

Fig. 3.1 Laysan Island in the Northwestern Hawaiian Islands.

Laysan Island (lat. 25°42'N, long. 171°44'W) is located ca. 1,300 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1). This island lies within the Hawaiian Islands National Wildlife Refuge and is one of the 6 primary haulout and pupping locations of the Hawaiian monk seal (Fig. 3.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Laysan Island in 1981. In 2001, research was conducted by NMFS during March 18-July 26 and October 5-19. Incidental observations were recorded by U.S. Fish and Wildlife Service (USFWS) personnel during the remainder of the year. The perimeter of the island (ca. 11 km) was divided into 20 sectors using artificial or natural landmarks (Fig. 3.1). Research objectives specific to this subpopulation in 2001 included (1) assessment of maternity and pup exchanges; (2) documentation of male behavior, including aggression; (3) observation of seals for signs of ill health; and (4) epidemiological sampling for health and disease assessment studies. The latter 2 objectives were added in late March when 4 young seals were found dead over a 1-week period leading to declaration of an unusual mortality event (UME). October research objectives included satellite transmitter deployment, epidemiological sampling, and retagging.

Censuses and Patrols

Census, patrols, and incidentals were scheduled to ensure that the entire island perimeter was monitored at least once daily during March 29-July 13. Censuses (n = 25) were conducted by 2 observers every fourth day from April 14 to July 21, beginning at 1300 Hawaii Standard Time and continuing for 2.0 to 3.1 h.

Standardized behavior patrols (n = 21) were conducted on noncensus days from April 16 to July 11 to assess behavior of adults and large subadults, including male aggression. During behavior patrols, observer attention was directed out to sea as much as possible, as multiple male aggression has been observed most frequently in the water.

Full-island standardized incidental surveys (n = 67) were conducted on noncensus and nonbehavior patrol days from March 18 to July 12 to record females with pups, weaned pups, injured seals, and molting animals. If observed, major behavioral interactions (i.e., male aggression) were also recorded. Additional partial island incidental surveys were conducted as needed.

Individual Identification

A total of 302 individuals (266 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Bleach marks were applied to 231 seals, including 31 nursing pups. All weaned pups (n = 33) were tagged with Temple Tags and passive integrated transponder (PIT) tags. During epidemiological sampling in April, 2 juvenile females (known-age yearlings) were newly tagged with Temple Tags and PIT tags, and 3 males (2 juveniles and a subadult) were retagged with Temple tags or PIT tags. Two adults were newly tagged with Temple Tags and PIT tags in October; a female and an unidentified male with old tag holes. Additionally, 15 seals (7 adult males, 3 adult females, 1 subadult male, 1 subadult female, 2 juvenile females and a weaned female pup) were retagged with Temple tags and/or PIT tags in October.

Sample Collection

Eighty-six scat and 7 spew samples were collected. Skin punches were collected from 32 weaned pups during tagging, and from 23 older seals. Various epidemiological samples were collected from 14 seals during the April health and disease study. No molt samples were collected. Five necropsies were performed; tissue and skeletal samples were collected from each of the seal carcasses. The skull from a dead adult female was also collected. In total, 315 pieces of potentially entangling debris were inventoried; 313 items were securely stored on Laysan to be removed at a later date. The remaining 2 pieces were removed from entangled seals, collected, and brought back to Honolulu.

Special Studies

Health, Disease, and Foraging Ecology

In late March 2001, NMFS staff found and necropsied 4 dead seals (3 yearlings and one 2-year old) over a 1-week period at Laysan Island. Under provisions of the Marine Mammal Protection Act of 1972, the Working Group on Marine Mammal Unusual Mortality Events (UME) determined that a UME involving juvenile Hawaiian monk seals was occurring at Laysan. Declaration of the UME was based primarily on the deaths at Laysan Island, but deaths and unusual symptoms/behaviors were reported at other locations, and investigation of the UME included other primary monk seal subpopulations in the Northwestern Hawaiian Islands to assess possible range-wide impacts. A team was deployed to visit the islands, necropsy dead seals, visually evaluate the health of seals observed, collect epidemiology samples from all unhealthy looking seals, and sample healthy looking juveniles. New tagging, retagging, and PIT tagging of sampled seals occurred opportunistically.

Blood, fecal samples, virological and bacteriological swabs, and blubber biopsies were collected at Laysan Island from April 18 to April 27. Samples were collected from 3 unhealthy juvenile males and from 10 healthy immature seals including 2 subadults (a

male and female) and 8 juveniles (4 males and 4 females). Additional vaginal swabs were obtained without restraint from an adult female whose pup died perinatally. Although no additional juvenile deaths occurred, at least 3 of the yearlings sighted in March/April were no longer seen by July.

During October 2001, a field team of researchers from NMFS and Hubbs Sea World Research Institution was deployed (1) to attach satellite-linked dive recorders (SLDRs) in order to characterize at-sea habitat use, (2) to collect epidemiological sampled (blood, swabs, blubber, etc.) for health and disease assessment, and (3) to retag or newly tag seals to facilitate individual identification in the subpopulation. A total of 37 seals were handled. Thirty seals were sampled for the health and disease assessment and received SLDRs: 16 received SLDRs and temple and/or PIT tags (including 2 newly tagged weaned pups) and 14 received SLDRs only. In addition, 3 seals received Temple and/or PIT tags, and 4 seals were immediately released due to molt status.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 25 censuses was 89.4 seals (± 11.3) including pups, and 70.6 seals (± 11.2) excluding pups (Table 3.1). The total spring-summer subpopulation was 292 individuals, 256 excluding pups (Table 3.2). This number is a subset of the total identified in the calendar year. The overall sex ratio was 0.8:1 (130 males: 160 females). The numbers of tagged known-age seals born at Laysan Island during the period from 1983 to 2000, and resighted at any location in 2001, are summarized in Table 3.3.

Reproduction

At least 36 pups were born at Laysan Island in 2001; 33 were successfully weaned and 3 died perinatally (Table 3.4a). Nursing periods and measurements of weaned pups are summarized in Table 3.4b. The birth rate was measured as the number of pups born divided by the number of adult-sized females in the subpopulation X 100 was 40.9% ((36/88) X 100). At least 17 pup exchanges occurred between 13 nursing females; none were observed.

Interatoll Movement

Interatoll movement was documented for 21 seals that completed a total of 35 movements between Laysan Island and French Frigate Shoals, Lisianski Island, Pearl and Hermes Reef, or Maro Reef (Tables 3.5a and b).

Factors Affecting Survival

Attacks by large sharks, mounting attempts by male Hawaiian monk seals, entanglement in marine debris, emaciation, and a number of unknown factors led to 26 life-threatening conditions, which resulted in the confirmed deaths of 9 animals and the disappearance of 4 other seals (Table 3.6). Although no incidents of prolonged adult male aggression were observed, 3 females (2 adults and a subadult) suffered moderate or severe dorsal injuries indicative of male mounting. Four seals were entangled; 2 escaped unaided, 1 was released by observers, and the fate of 1 was unknown. In addition to the incidents presented in Table 3.6, one 3-year old was not seen after mid-April, two 2-year olds were not seen after mid-June, 2 yearlings were not seen after early May, and 1 yearling was not seen after late June. All these yearlings were in poor condition when they were last seen. An adult female of medium condition pupped and nursed her pup for 32 days; upon weaning she was obviously emaciated and not seen again after mid-June.

ACKNOWLEDGMENTS

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TABLES
for Laysan Island

Table 3.1.--Summary statistics for censuses (n = 25) of Hawaiian monk seals at Laysan Island from April 14 to July 21, 2001.

Size/Sex	Mean number of individuals	Standard deviation
Adults	45.2	7.2
Male	17.6	4.9
Female	26.0	5.1
Unknown	1.6	2.0
Subadults	14.8	5.1
Male	7.3	2.6
Female	7.2	3.2
Unknown	0.3	0.5
Juveniles	10.7	2.8
Male	5.2	1.7
Female	5.3	2.2
Unknown	0.2	0.4
Pups	18.8	3.3
Male	9.8	1.6
Female	8.9	2.3
Unknown	0.1	0.4
Non-pup total	70.6	11.2
Grand total	89.4	11.3

Table 3.2.--Composition of the Hawaiian monk seal subpopulation at Laysan Island during the spring and summer of 2001. Includes all known parturient females and pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	72	88	0	160	0.8:1
Subadults	26	28	0	54	0.9:1
Juveniles	16	26	0	42	0.6:1
Pups	16	18	2	36	0.9:1
Non-pup total	114	142	0	256	0.8:1
Grand total	130	160	2	292	0.8:1

Table 3.3.--Summary of tagged known-age seals born at Laysan Island and resighted at any location in 2001.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2001
1983	18	Male	10	1
		Female	10	6
1984	17	Male	16	2
		Female	13	5
1985	16	Male	16	1
		Female	14	4
1986	15	Male	15	0
		Female	17	2
1987	14	Male	13	3
		Female	15	6
1988	13	Male	23	4
		Female	17	3
1989	12	Male	16	2
		Female	13	2
1990	11	Male	7	2
		Female	9	3
1991	10	Male	18	7
		Female	13	4
1992	9	Male	18	2
		Female	14	4
1993	8	Male	23	4
		Female	14	5
1994	7	Male	18	8
		Female	29	8
1995	6	Male	16	7
		Female	21	9
1996	5	Male	23	11
		Female	21	11
1997	4	Male	19	5
		Female	16	7
1998	3	Male	24	15
		Female	20	10
		Unknown	1	0
1999	2	Male	20	9
		Female	34	22
2000	1	Male	14	7
		Female	20	9

Table 3.4a.--Summary of Hawaiian monk seals born at Laysan Island in 2001.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	16	18	2	36
Died prior to weaning	0	1	2	3
Weaned	16	17	0	33
Tagged	16[a]	17[b]	0	33

[a, b]Includes 2 pups weaned in August and tagged by the October NMFS camp.

Table 3.4b.--Summary of nursing periods and measurements of weaned pups at Laysan Island in 2001. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	36.6	100.1	124.2
Standard deviation	3.7	12.4	8.1
n	32	31	31

Table 3.5a.–Documented movement of Hawaiian monk seals to Laysan Island from other locations in 2001, summarized by movements between two locations. Three seals made more than 1 observed trip.

Original location	Number of trips, size, and sex class
French Frigate Shoals	1 adult female
Lisianski Island	13 adult female 2 subadult male 1 subadult female 1 juvenile female
Pearl and Hermes Reef	1 subadult female

Table 3.5b.–Documented movement of Hawaiian monk seals from Laysan Island to other locations in 2001, summarized by movements between 2 locations. Two seals made more than 1 observed trip.

Destination	Number of trips, size, and sex class
French Frigate Shoals	1 adult male
Lisianski Island	10 adult female 2 subadult male 1 subadult female
Pearl and Hermes Reef	1 juvenile male
Maro Reef	1 weaned male pup

Table 3.6.--Factors affecting Hawaiian monk seal survival at Laysan Island in 2001.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
		Attack by Large Shark			
Adult	Male	3	3	0	0
	Female	2	1	0	1
Juvenile	Male	1	1	0	0
Weaned Pup	Female	1	1	0	0
		Mounting by Males			
Adult	Female	2[a]	2	0	0
Subadult	Female	1	1	0	0
		Entanglement			
Adult	Male	2[b]	0	0	0
	Female	1[c]	0	0	0
Unknown	Unknown	1[d]	0	0	0
		Emaciation			
Adult	Male	1	0	0	1[e]
Juvenile	Male	2	0	0	2[f]
		Unknown			
Adult	Male	1	0	1[g]	0
	Female	1	0	1	0
Juvenile	Male	1	0	1[h]	0
	Female	3	0	3[i]	0
Nursing pup	Female	1	0	1[j]	0
	Unknown	2	0	2[k]	0

[a] Includes 1 seal whose pup died perinatally.

[b] One seal was released by observers and sustained no injuries. The other seal was observed entangled in November by USFWS personnel but freed itself by Jan 2002.

[c] Seal disentangled itself and sustained no injuries from the entanglement.

[d] Untagged seal was observed entangled in November by USFWS, fate unknown.

[e] An older seal in extremely poor, deteriorating condition and noted as lethargic.

[f] One seal in deteriorating condition, emaciated with wobbly movements. The other seal had minor shark injuries, poor to very thin condition with lethargic/abnormal behaviors noted several times.

[g] Seal washed up after a storm with its head and a large portion of its abdominal area missing. It is unknown whether these injuries were sustained pre- or post-mortem.

[h] One of 4 seals that died within a week period, appeared to be in good condition.

[i] Three of the 4 seals that died within a week period. Seals appeared to be thin.

[j] Pup was never observed alive.

[k] Includes 1 pup who was born alive but appeared to have difficulty moving its left foreflipper; researchers observed the pup drown.

CHAPTER 4. THE HAWAIIAN MONK SEAL ON LISIANSKI ISLAND, 2001

Jacqueline M. Pearson, Erin T. McCarthy, and Erin E. Moreland

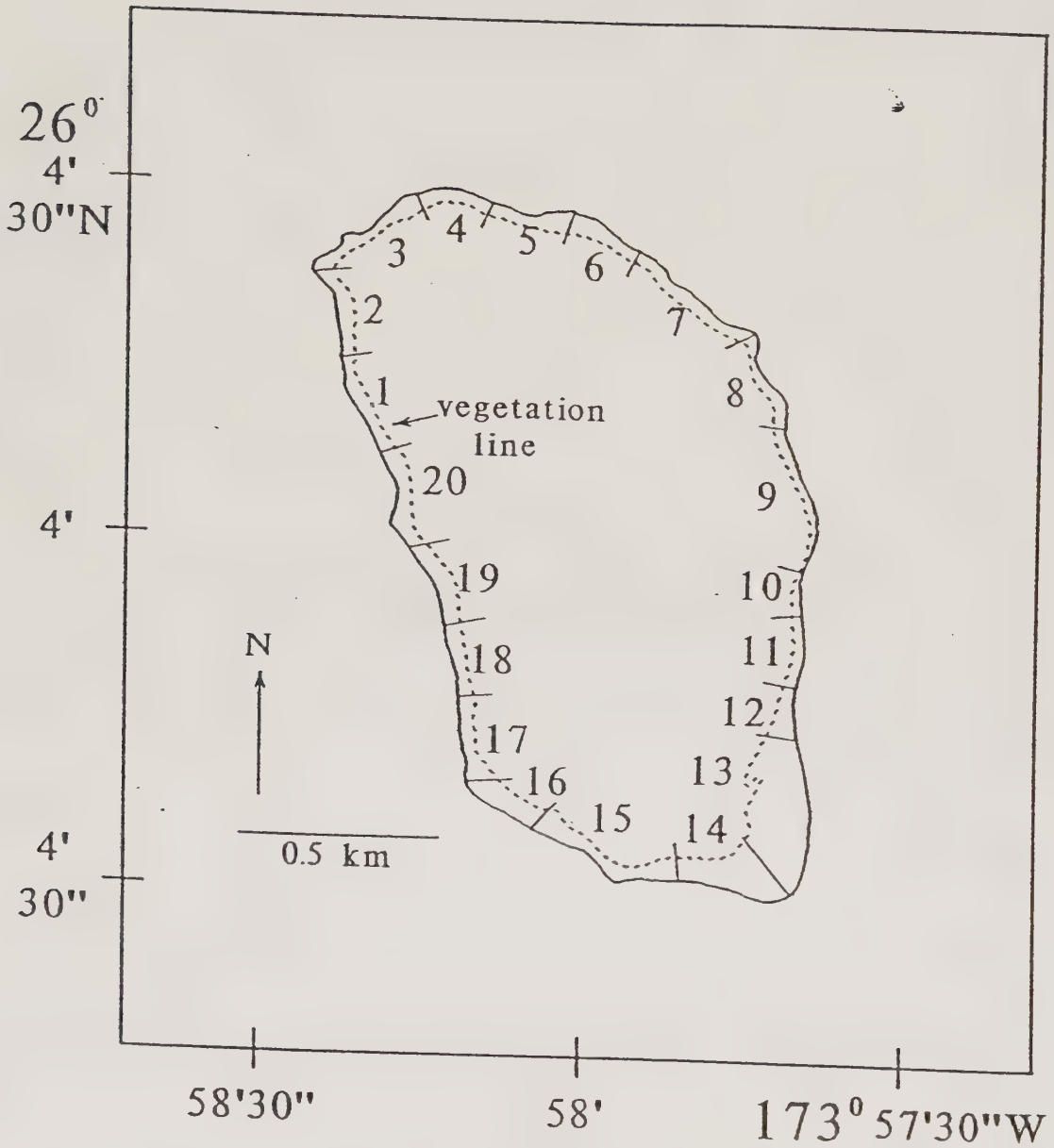

Fig. 4.1 Lisianski Island in the Northwestern Hawaiian Islands.

Lisianski Island (lat. 26°02'N, long. 174°00'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. The island is located ca. 1,760 km northwest of Oahu (Fig. 1.1) and is surrounded by Neva Shoal, a shallow reef bank within the Hawaiian Islands National Wildlife Refuge (Fig. 4.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Lisianski Island in 1980. In 2001 research was conducted by NMFS during March 12-July 22. Additional observations were conducted opportunistically by the USFWS during August 15, 2001. The perimeter of the island was divided into 20 sectors using artificial or natural landmarks (Fig. 4.1). Research activities specific to this subpopulation in 2001 included (1) assessment of maternity and pup exchanges; (2) documentation of male behavior, including aggression; (3) observing seals for signs of ill health; (4) epidemiological sampling for health and disease assessment studies; and (5) observations of seals satellite tagged in October 2000. Objectives 3 and 4 were added after 4 seals were found dead within the first week of camp deployment. The seals found dead were 1 perinatal pup, 1 juvenile, 1 adult, and 1 subadult seal.

Censuses and Patrols

Census, patrols and incidentals were scheduled to ensure that the entire island was monitored at least once daily during March 12-July 22. Censuses (n = 28) were conducted by 2 observers every fourth day from March 21 to July 12, beginning at 1300 Hawaii Standard Time and continuing from 1.5 to 2.8 h.

Standardized behavior patrols were conducted on 28 noncensus days from March 19 to July 9 to assess behaviors of adults and large subadults, including male aggression. During behavior patrols (n = 28), attention was directed out to sea as much as possible since multiple male aggression has been observed most frequently in the water.

Full-island standardized incidental surveys (n = 67) were conducted on noncensus and nonbehavior patrol days during March 12- July 22 to record females with pups, sick or injured seals, weaned pups, molting animals, and satellite-tagged seals. If observed, major behavioral interactions (i.e., male mobbing/harassments) were also recorded. Additional partial island surveys were conducted as needed.

Individual Identification

A total of 183 individuals (166 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Bleach marks were applied to 143

individual seals, including 14 nursing pups. All weaned pups (n = 14) were tagged with Temple tags and passive integrated transponder (PIT) tags (1 of these pups was subsequently retagged twice in 2001).

Collection of Samples

One hundred-two scat and 3 spew samples were collected. Skin punches were collected from 14 weaned pups during tagging. Four necropsies were performed; tissue and skeletal samples were collected from the seal carcasses. Additional tissue and skeletal samples were collected from 1 adult male, and the skull from 1 subadult seal of undetermined sex (both carcasses were too decomposed for a full necropsy). Various epidemiology samples were collected from 2 juvenile seals (a male and female) during the April health and disease study. Shed molt samples were collected from 10 individuals. In total, 326 items of potentially entangling debris were inventoried; of these, 325 items were stored to be removed from the island at a later date. One item removed from an entangled seal was collected and brought to Honolulu.

Special Studies

Health and Disease

Under provisions of the Marine Mammal Protection Act of 1972, the Working Group on Marine Mammal Unusual Mortality Events (UME) determined that a UME involving juvenile Hawaiian monk seals was occurring at Laysan (see the Laysan Island chapter). A team visited Lisianski Island on April 17 and collected blood, fecal samples, virological and bacteriological swabs, and blubber biopsies from 2 healthy juvenile seals (a 2-year-old male and a 3-year-old female).

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 28 censuses was 58.2 seals (± 6.8) including pups, and 49.1 seals (± 6.2) excluding pups (Table 4.1). The total spring-summer subpopulation was 178 individuals, 161 excluding pups (Table 4.2). This number is a subset of the total identified in the calendar year. The sex ratio for older (>19 years of age) and unknown aged adults was strongly skewed toward males at 2.5:1 (30 males:12 females), whereas the ratio for younger adults (≤ 19 years of age) was at 0.9:1 (33 males: 37 females). The numbers of tagged known-age seals born at Lisianski Island during the period from 1982 to 2000, and resighted at any location in 2001, are summarized in Table 4.3.

Reproduction

At least 17 pups were born at Lisianski Island in 2001: 14 were successfully weaned, 2 died perinatally, and 1 probably died (Table 4.4a). Nursing periods and measurements of weaned pups are summarized in Table 4.4b. The birth rate measured as the number of pups born divided by the number of adult-sized females in the subpopulation X 100 was 34.7% ((17/49) X 100). A minimum of 3 pup exchanges occurred among 15 nursing females; researchers observed 1 of these incidents.

Interatoll Movement

Interatoll movement was documented for 17 seals that completed a total of 31 movements between Lisianski Island and either Laysan Island or Kure Atoll (Tables 4.5a and b).

Factors Affecting Survival

Attacks by large sharks, entanglement in marine debris, emaciation, and other/unknown factors led to 23 life-threatening conditions, which resulted in the confirmed deaths of 6 animals and the probable death of 5 seals (Table 4.6). Two seals were entangled, and subsequently released by observers with no further evident complications. No incidents of prolonged adult male aggression or serious mounting injuries were observed. In addition to the cases summarized in Table 4.6, an adult female still had a chronic injury observed in previous field seasons, and the mummified carcass of a subadult/adult seal of unknown sex was found at the beginning of the season. This seal had died of unknown causes since the previous field season.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff. We thank the captain, officers, and crew of the NOAA ship *Townsend Cromwell* and the *SS Midway* for logistical assistance.

TABLES
for Lisianski Island

Table 4.1.--Summary statistics for censuses (n = 28) of Hawaiian monk seals at Lisianski Island from March 21 to July 12, 2001.

Size/Sex	Mean number of individuals	Standard deviation
Adults	35.7	4.7
Male	17.5	3.6
Female	15.6	2.9
Unknown	2.5	1.7
Subadults	8.9	2.1
Male	6.1	1.8
Female	2.4	1.8
Unknown	.4	.6
Juveniles	4.5	2.0
Male	1.8	1.3
Female	2.6	1.4
Unknown	0.0	.2
Pups	9.0	2.6
Male	3.0	1.2
Female	6.0	1.7
Unknown	0.0	0.2
Non-pup total	49.1	6.2
Grand total	58.2	6.8

Table 4.2.--Composition of the Hawaiian monk seal subpopulation at Lisianski Island during the spring and summer of 2001. Includes all known parturient females and all pups born during the calendar year.

Size	Number of seals				Sex ratio male:female
	Male	Female	Unknown	Total	
Adults	63	49	0	112	1.3:1
Subadults	19	10	0	29	1.9:1
Juveniles	9	11	0	20	0.8:1
Pups	5	10	2	17	0.5:1
Non-pup total	91	70	0	161	1.3:1
Grand total	96	80	2	178	1.2:1

Table 4.3.--Summary of tagged known-age seals born at Lisianski Island and resighted at any location in 2001.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2001
1982	19	Male	7	2
		Female	6	1
1983	18	Male	6	2
		Female	18	7
1984	17	Male	10	4
		Female	5	2
1985	16	Male	5	2
		Female	9	1
1986	15	Male	11	5
		Female	9	3
1987	14	Male	12	1
		Female	6	1
1988	13	Male	10	5
		Female	8	6
1989	12	Male	–	–
		Female	--	--
1990	11	Male	8	4
		Female	9	3
1991	10	Male	9	4
		Female	6	2
1992	9	Male	13	6
		Female	8	4
1993	8	Male	4	1
		Female	9	2
1994	7	Male	4	1
		Female	5	1
1995	6	Male	7	2
		Female	10	2
1996	5	Male	9	2
		Female	13	1
1997	4	Male	10	5
		Female	9	3
1998	3	Male	10	3
		Female	11	6
1999	2	Male	16	7
		Female	11	3
2000	1	Male	9	2
		Female	9	4

Table 4.4a.--Summary of Hawaiian monk seals born at Lisianski Island in 2001.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	5	10	2	17
Died/Probably died prior to weaning	0	1	2	3
Weaned	5	9	0	14
Tagged	5	9	0	14

Table 4.4b.--Summary of nursing periods and measurements of weaned pups at Lisianski Island in 2001. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	36.3	103.5	124.6
Standard deviation	4.8	11.8	9.0
n	12	14	14

Table 4.5a.–Documented movement of Hawaiian monk seals to Lisianski Island from other locations in 2001, summarized by movements between 2 locations. Two seals made more than 1 observed trip.

Original location	Number of trips, size, and sex class
Laysan Island	10 adult female 2 subadult male 1 subadult female

Table 4.5b.–Documented movement of Hawaiian monk seals from Lisianski Island to other locations in 2001, summarized by movements between 2 locations. Three seals made more than 1 observed trip.

Destination	Number of trips, size, and sex class
Laysan Island	13 adult female 2 subadult male 1 subadult female 1 juvenile female
Kure Atoll	1 subadult male

Table 4.6.--Factors affecting Hawaiian monk seal survival at Lisianski Island in 2001.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
		Attack by Large Shark			
Adult	Male	7	6	0	1
	Female	1	1	0	0
Subadult	Male	1	1	0	0
	Female	2	2	0	0
Juvenile	Female	1	0	0	1
		Mounting by Male			
		(none observed)			
		Entanglement			
Adult	Male	1[a]	0	0	0
	Female	1[a]	0	0	0
		Emaciation			
Adult	Male	1	0	0	1
	Female	1[b]	0	1	0
Juvenile	Female	2	0	1	1
		Other/Unknown			
Subadult	Male	1	0	1	0
Juvenile	Male	1	0	1	0
Nursing Pup	Female	1	0	1	0
	Unknown	2	0	1	1

[a] Seal released by observers.

[b] The adult female was emaciated post weaning, suffered 2 separate shark injuries, and eventually died.

CHAPTER 5. THE HAWAIIAN MONK SEAL ON PEARL AND HERMES REEF, 2001

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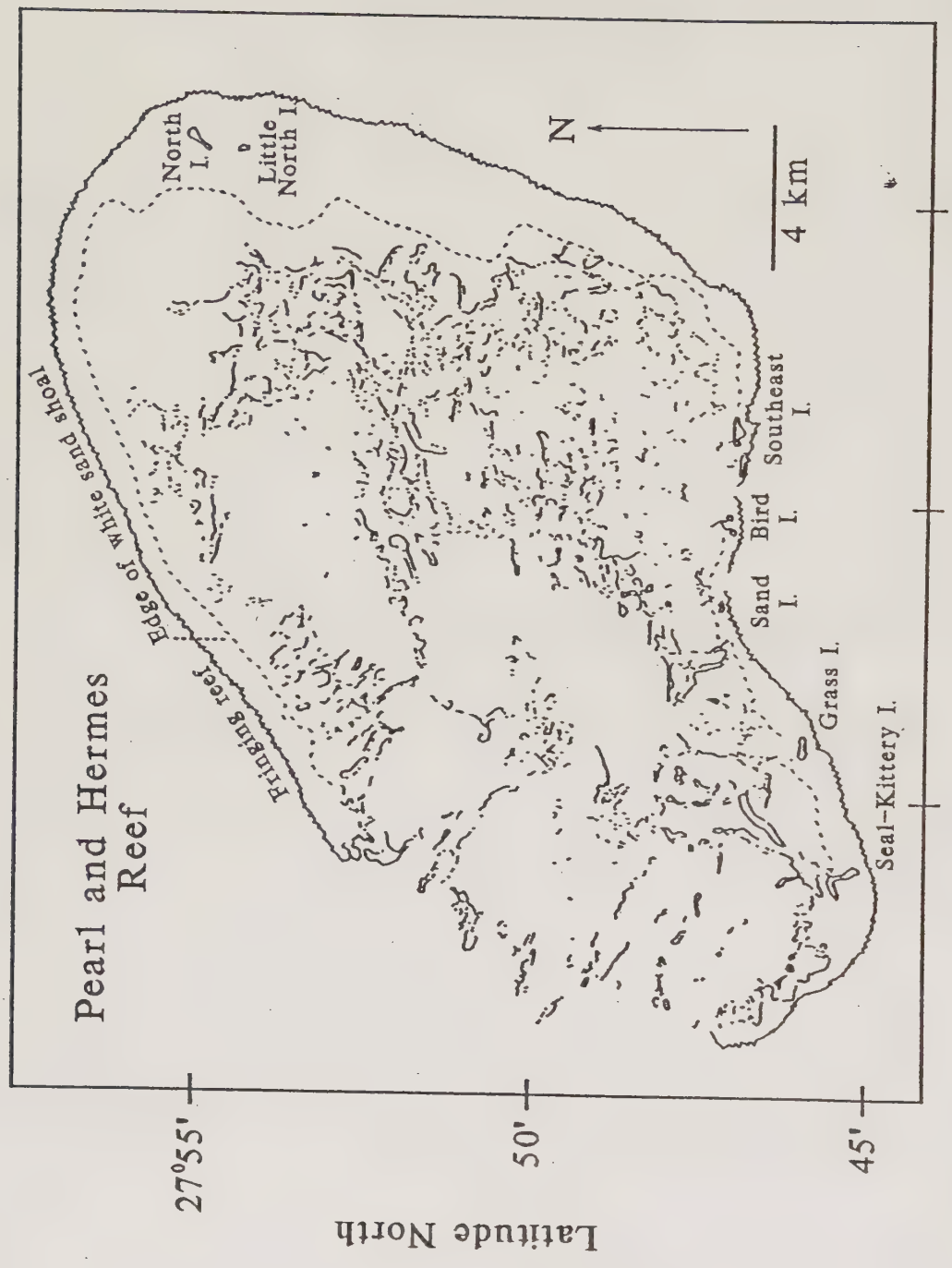

Fig. 5.1 Pearl and Hermes Reef in the Northwestern Hawaiian Islands.

Pearl and Hermes Reef (lat. 27°55'N, long. 175°45'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. This atoll is located ca. 1,900 km northwest of Oahu in the Northwestern Hawaiian Islands and is part of the Hawaiian Islands National Wildlife Refuge (Fig. 1.1). Pearl and Hermes is composed of 4 vegetated and 3 nonvegetated sand islets enclosed in a fringing reef (Fig. 5.1).

RESEARCH

The National Marine Fisheries Service (NMFS) began research on Hawaiian monk seals at Pearl and Hermes Reef in 1982. In 2001, research was conducted by NMFS during April 15 and from May 20 to July 22. Incidental observations were recorded by U.S. Fish and Wildlife Service (USFWS) personnel on August 11 and October 3. The perimeters of the 4 larger vegetated islets were divided into sectors using natural landmarks. Research activities specific to this subpopulation in 2001 included opportunistic patrols of the emergent reef.

Censuses and Patrols

Atoll censuses ($n = 8$) were conducted every fourth day, on average, from May 29 to July 5. Each atoll census began between 0937 and 1024 and ended between 1433 and 1607 Hawaii Standard Time. All islets were censused on foot by 1 or 2 persons. Incidental patrols were conducted opportunistically to resight seals tagged in previous years and to identify and bleach-mark all animals in the subpopulation. In addition, surveys of the emergent reef were conducted by boat and kayak to determine whether a significant number of animals use these areas as haulout sites and should be surveyed on a regular basis.

Individual Identification

A total of 249 individuals (217 excluding pups) were identified by existing or applied tags, scars, or natural markings. Twenty-five weaned pups were tagged with Temple Tags and passive integrated transponder (PIT) tags. In addition, a juvenile male was newly tagged with Temple Tags and a PIT tag, and an adult female was retagged with Temple Tags.

Collection of Samples

Forty scat and 1 spew samples were collected. Skin punches were collected from 23 weaned pups and from 2 other seals during tagging. Various epidemiological samples were collected from 8 seals during the April-May health and disease study. In total, 24

items of potentially entangling debris were inventoried and stored for future removal by ship.

Special Studies

Health and Disease

Under provisions of the Marine Mammal Protection Act of 1972, the Working Group on Marine Mammal Unusual Mortality Events (UME) determined that a UME involving juvenile Hawaiian monk seals was occurring at Laysan (see the Laysan Island chapter). A team visited Pearl and Hermes Reef on April 15 and May 20-21 and collected blood, fecal samples, virological and bacteriological swabs, and blubber biopsies from an unhealthy juvenile male, 6 healthy juvenile seals (3 male and 3 female), and from an adult female sampled incidental to a disentanglement.

Emergent Reef Surveys

In 2001, preliminary surveys were conducted to characterize seal haulout patterns on the emergent reef and determine if a subset of the seals at Pearl and Hermes Reef were hauling out solely on the barrier reef and not being observed on the islands. One boat survey and 1 kayak survey were conducted to compare survey methods.

During both surveys seals were observed on the reef. Because of the shallow areas surrounding the fringing reef, boats were unable to approach close enough to identify any seals. Kayaks allowed for a closer inspection of the reef areas, and therefore produced a more accurate count of seals hauled out and allowed for individual identification of 90% of the animals sighted.

The majority of the seals sighted on the fringing reef were juvenile and subadult animals. In the single kayak survey, 3 juvenile seals were observed that had not been sighted elsewhere on land. In addition, 1 weaned pup was resighted that had been bleached and not tagged, confirming its existence.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 8 atoll censuses was 100.1 seals (±8.6) including pups and 80.8 seals (±9.5) excluding pups (Table 5.1). The total summer subpopulation was 243 individuals, 211 excluding pups (Table 5.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Pearl and Hermes Reef during the period from 1983 to 2000, and resighted at any location in 2001, are summarized in Table 5.3.

Reproduction

At least 32 pups were born at Pearl and Hermes Reef in 2001: 26 were successfully weaned, 2 were found dead, and 4 were still nursing at the end of the research period (Table 5.4). The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation X 100, was 44.4% ((32/72) X 100). Nursing periods and measurements of weaned pups are summarized in Table 5.4.

Interatoll Movement

Interatoll movement was documented for 18 seals that completed a total of 24 movements between Pearl and Hermes Reef and either Laysan Island, Midway Atoll, or Kure Atoll (Tables 5.5a and b).

Factors Affecting Survival

Entanglement in marine debris and unknown factors resulted in 8 life-threatening conditions (Table 5.6). During 2001, 3 juvenile seals were found dead (1 male and 2 females). One was discovered during the first patrol of Seal Kittery, another was found on Peanut during the middle of the season, and the third was found in August on Southeast after the main field season. All carcasses were found too decomposed to necropsy. In addition, 2 pups were found dead at the beginning of the season. Both were small pups, 1 with its umbilicus still attached. One adult female and 1 juvenile male were disentangled from debris. The adult female sustained lacerations around her neck. All wounds were observed healed later in the season. One subadult female seal was observed with a large gaping wound on the side of her head. The wound was observed healing throughout the season. In addition to the incidents presented in Table 5.6, 1 subadult and 2 adult seals were observed with unilateral clouded eyes, and 2 juveniles (a male and female) were emaciated in October, after the main field season.

ACKNOWLEDGMENTS

We thank the captain, officers, and crew of the NOAA Ship *Townsend Cromwell*. We also acknowledge the support of the U.S. Fish and Wildlife Service, Hawaiian Islands National Wildlife Refuge staff.

TABLES
for Pearl and Hermes Reef

Table 5.1.--Summary statistics for atoll censuses (n =8) of the Hawaiian monk seal at Pearl and Hermes Reef from May 29 to July 5, 2001.

Size/Sex	Mean number of individuals	Standard deviation
Adults	57.0	6.0
Male	21.1	3.9
Female	28.8	3.1
Unknown	7.1	2.0
Subadults	9.9	3.6
Male	4.0	2.3
Female	4.4	1.9
Unknown	1.5	1.7
Juveniles	13.3	2.5
Male	5.9	1.6
Female	6.8	1.2
Unknown	0.6	0.9
Pups	19.4	2.3
Male	11.9	2.0
Female	6.5	1.4
Unknown	1.0	1.2
Non-pup total	80.8 [a]	9.5
Grand total	100.1 [a]	8.6

[a] Total includes some seals which were not placed in any size class.

Table 5.2.--Composition of the Hawaiian monk seal subpopulation at Pearl and Hermes Reef during the spring and summer of 2001. Includes all known parturient females and pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	63	72	0	135	0.9:1
Subadults	14	19	0	33	0.7:1
Juveniles	21	22	0	43	1.0:1
Pups	18	10	4	32	1.8:1
Non-pup total	98	113	0	211	0.9:1
Grand total	116	123	4	243	0.9:1

Table 5.3.--Summary of tagged known-age seals born at Pearl and Hermes Reef and resighted at any location in 2001.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2001
1983	18	Male	8	1
		Female	2	1
1984	17	Male	5	1
		Female	8	3
1985	16	Male	9	2
		Female	6	3
1986	15	Male	10	2
		Female	7	2
		Unknown	1	0
1987	14	Male	14	5
		Female	7	3
1988	13	Male	12	6
		Female	6	4
1989	12	Male	8	3
		Female	6	2
1990	11	Male	5	3
		Female	1	0
1991	10	Male	10	7
		Female	11	6
1992	9	Male	13	7
		Female	10	8
1993	8	Male	14	5
		Female	7	4
1994	7	Male	--	--
		Female	--	--
1995	6	Male	15	5
		Female	12	5
1996	5	Male	11	2
		Female	12	5
1997	4	Male	16	8
		Female	11	6
1998	3	Male	8	3
		Female	21	16
1999	2	Male	11	8
		Female	15	8
2000	1	Male	12	10
		Female	10	6

Table 5.4a.--Summary of Hawaiian monk seals born at Pearl and Hermes Reef in 2001.

Event	Number of pups			
	Male	Female	Unknown	Total
Born	18	10	4	32
Died prior to weaning	0	0	2	2
Still nursing	1	1	2	4
Weaned	17	9	0	26
Tagged	16	9	0	25

Table 5.4b.--Summary of nursing periods and measurements of weaned pups at Pearl and Hermes Reef in 2001. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	35.4	105.7	124.9
Standard deviation	6.4	8.3	7.0
n	5	15	16

Table 5.5a.–Documented movement of Hawaiian monk seals to Pearl and Hermes Reef from other locations in 2001, summarized by movements between 2 locations. No seals made more than 1 observed trip.

Original location	Number of trips, size, and sex class
Laysan Island	1 juvenile male
Midway Atoll	2 adult male 6 adult female
Kure Atoll	1 adult female

Table 5.5b.–Documented movement of Hawaiian monk seals from Pearl and Hermes Reef to other locations in 2001, summarized by movements between 2 locations. One seal made more than 1 observed trip.

Destination	Number of trips, size, and sex class
Laysan Island	1 subadult female
Midway Atoll	4 adult male 6 adult female 1 weaned pup male
Kure Atoll	1 adult female 1 subadult male

Table 5.6.--Factors affecting Hawaiian monk seal survival at Pearl and Hermes Reef in 2001.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
(none observed)					
Mounting by Males					
(none observed)					
Entanglement					
Adult	Female	1[a]	1	0	0
Juvenile	Male	1[a]	0	0	0
Unknown					
Subadult	Female	1	1	0	0
Juvenile	Male	1	0	1	0
	Female	2	0	2	0
Nursing pup	Unknown	2	0	2	0

[a]Seal released by observers.

CHAPTER 6. THE HAWAIIAN MONK SEAL ON MIDWAY ATOLL, 2001

Bruce R. Casler, Andrea D. Shluker, Patti A. Haase

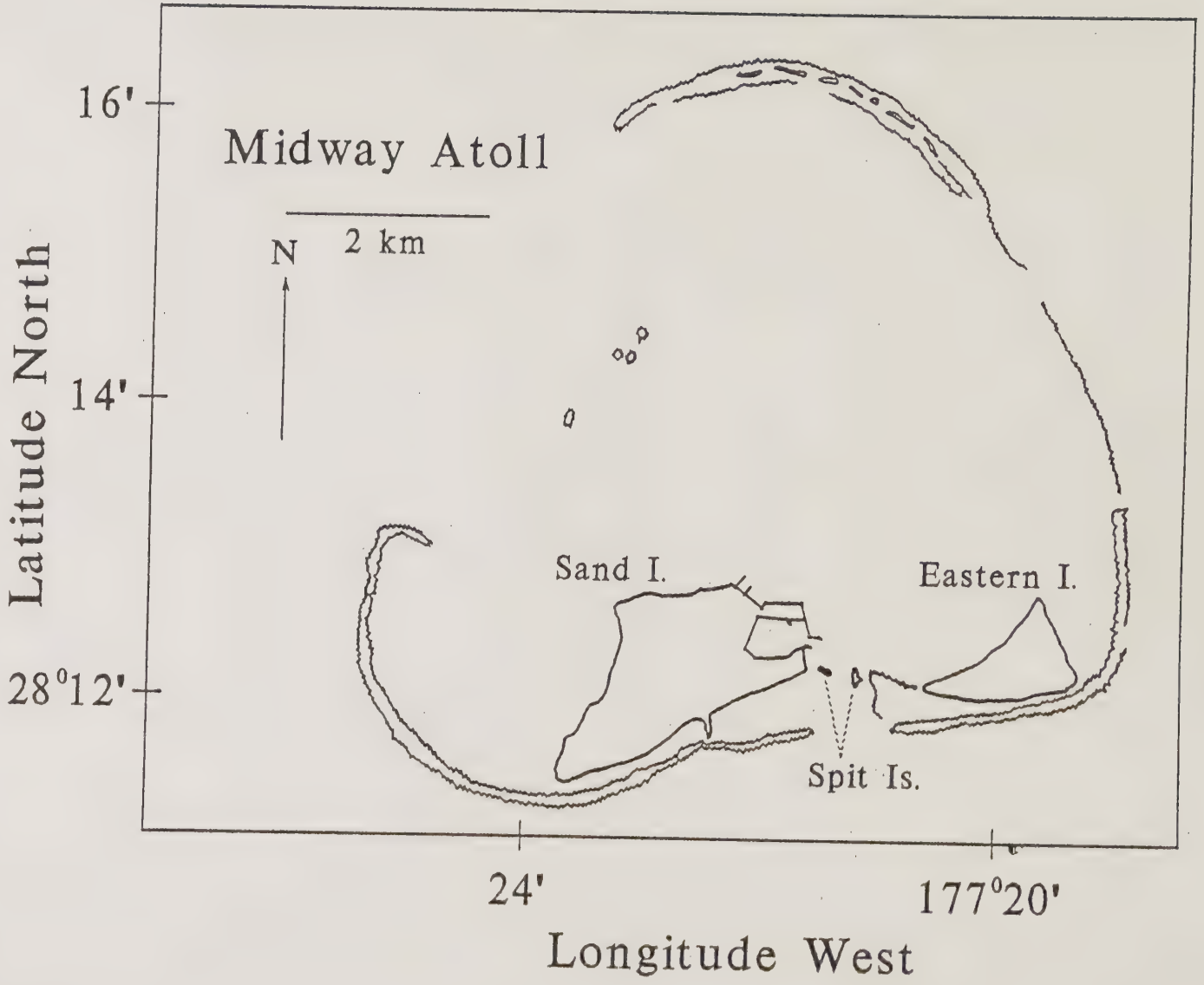

Fig. 6.1 Midway Atoll in the Northwestern Hawaiian Islands.

Midway Atoll (lat. 28°14'N, long. 177°22'W) is one of the primary haulout and pupping locations of the endangered Hawaiian monk seal. This atoll is located ca. 2,100 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1) and comprises a circular atoll approximately 9 km in diameter, enclosing a lagoon and 3 permanent islets inside the southern part of the reef (Fig. 6.1). Eastern and Spit are uninhabited. Sand Island was the site of a U.S. Naval Air base from ca. 1939 until 1993. The U.S. Fish and Wildlife Service (USFWS) had maintained an overlay refuge (Midway Atoll National Wildlife Refuge) at the site since 1988 until full authority was transferred to the USFWS in October 1996. In 1996, USFWS joined Midway Phoenix Corporation (MPC) in a cooperative agreement. Through this agreement MPC maintained the infrastructure and operated the airport and harbor. Additionally, this agreement enabled MPC to operate ecotourism and recreational ventures.

Beach counts of the Hawaiian monk seal at Midway Atoll averaged 56 animals in the late 1950s (Kenyon, 1972) but declined severely by the late 1960s; a single seal was observed during an aerial survey in 1968 (Kenyon, 1972). Currently, recovery is underway because of immigration from nearby Kure Atoll and Pearl and Hermes Reef and an increasing number of seals born on Midway Atoll. Recovery of this subpopulation remains an important management goal (Gilmartin and Antonelis, 1998).

RESEARCH

The National Marine Fisheries Service (NMFS) began limited monitoring of Hawaiian monk seals at Midway Atoll in 1983. This effort was increased to year-round monitoring in 1997 in collaboration with researchers from Oceanic Society (OS) and Hawaii Wildlife Fund (HWF). HWF concluded its year-around monitoring program in January 2000, and research continued through a contract agreement between NMFS and USFWS from February to September 2000. In 2001, research was conducted by NMFS from January 1 to January 6 and February 25 to September 4. Incidental observations of seals, disturbance monitoring of public beaches, and public education lectures were conducted by USFWS and OS personnel throughout the year.

Perimeters of the 3 permanent islets were divided into sectors using artificial or natural landmarks. Research activities specific to this subpopulation in 2001 included (1) beach counts and monitoring; (2) emergent reef surveys to determine haulout patterns in these areas; (3) satellite tag deployment for a foraging ecology study, with blood and tissue sampling for health assessment purposes taking place at the same time; (4) survey for and removal of marine debris from the north and east reef flats, emergent reef areas, and all beaches; and (5) monitoring human impacts on seals to quantify occurrence and potential effects on monk seal habitat usage.

Censuses and Patrols

Atoll censuses (n = 25) were conducted every seventh day, on average, from March 7 to August 29. Each atoll census began between 0726 and 1650, and ended between 1000 and 1740 Hawaii Standard Time. All islets were censused on foot by 1 or 2 persons. Patrols of Sand Island (n = 57), Eastern (n = 60), or Spit (n = 50) were conducted on nonatoll census days during January 10-September 4.

Individual Identification

A total of 81 individuals (66 excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. Eleven weaned pups were tagged with Temple tags and passive integrated transponder (PIT) tags. One pup that disappeared shortly after birth was not tagged. During the satellite telemetry study, an adult female was newly tagged with Temple Tags and a PIT tag, 2 adult males were retagged with Temple tags and PIT tags, and 2 subadults were retagged with Temple tags (a male and female).

Collection of Samples

Skin punches were collected from 11 weaned pups during tagging. Three spews, 55 scats, and 27 shed molt samples were also collected. One necropsy was performed and tissue samples were taken. Blood, fecal, and tissue samples were collected from 16 seals during the satellite telemetry project in January and from 2 seals during the health and disease study in May. Four hundred eighteen items of potentially entangling marine debris totaling approximately 2,514 kg were collected by NMFS and OS personnel and were either destroyed at Midway or stored on Midway for removal by NOAA or Coast Guard ships. USFWS also conducted a marine debris removal program with staff and volunteers and collected an unknown number of lines and nets totaling 6,375 kg, bringing the total amount of debris removed at Midway from January through August to 8,889 kg.

Special Studies

Foraging Ecology, Health, and Disease

In January 2001, researchers from NMFS, Hubbs-Sea World Research Institute and Sea World of Texas began a study on movements and foraging behavior of Hawaiian monk seals at Midway. Sixteen seals (4 adult, 6 subadult, and 6 juveniles) were outfitted with satellite-linked dive recorders that collect data on diving patterns and geographic locations for each seal. During the restraint of these seals, blood and tissue samples were taken for health assessment purposes. Assistance for this project was also provided by USFWS.

Under provisions of the Marine Mammal Protection Act of 1972, the Working Group on Marine Mammal Unusual Mortality Events (UME) determined that a UME involving juvenile Hawaiian monk seals was occurring at Laysan (see the Laysan Island chapter). A team visited Midway Atoll on May 11-16 and collected blood, fecal samples, virological and bacteriological swabs, and blubber biopsies from 2 unhealthy juvenile males.

Emergent Reef Surveys

Patrols were conducted 1-2 times per week, depending on weather conditions, along the emergent reef areas of the North Reef (n = 28) and East Reef (n = 28) from January 29 to August 30. Two people using kayaks and a motorboat surveyed the reefs for seals and turtles. On 15 occasions, both emergent reef areas were surveyed within 1 day of atoll counts to provide an estimate of atoll-wide beach/emergent reef counts.

Noteworthy Events

Beach Monitoring and Public Education

During 2001, Sand Island beaches and trails were monitored for potential monk seal disturbance and refuge violations. Most of the disturbance monitoring took place in public use areas, but information about potential disturbance was also collected during standard monk seal surveys of Sand Island's closed beaches. A minimum of 2 disturbance patrols were conducted every day (morning and evening), with more being done as needed, depending on the presence and locations of seals. In all, from January 1 to August 31, 437 hours were spent conducting 421disturbance patrols, and 252 hours were spent conducting 82 standard monk seal censuses.

Other actions taken during the field season to help mitigate disturbance to seals at Midway and support the desire of USFWS to maintain "visitor friendly" directives included the continuation of the "red seal" sign system, alerting residents and guests of a seal's presence in public-use areas on Sand Island. These signs were put in place near resting seals 255 times.

Informational lectures were presented weekly to island residents, visiting students and researchers, and general visitors. Topics covered included monk seal natural history, current information about Midway's subpopulation, NMFS recovery efforts and recovery team priorities, and the reasons for refuge rules governing seal viewing and beach closures.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 25 atoll censuses was 23.4 seals (±4.9) including pups, and 18.7 seals (±5.1) excluding pups (Table 6.1). The total spring-summer subpopulation was 67 seals, 55 excluding pups (Table 6.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Midway Atoll during the period from 1988 to 2000, and resighted at any location in 2001, are summarized in Table 6.3.

Reproduction

A minimum of 12 pups were born at Midway Atoll in 2001, 11 successfully weaned, and 1 disappeared within 3 days after being born, and probably died (Table 6.4a). The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation X 100 was 52.2% ((12/23) X 100). No pup exchanges occurred between nursing females. Nursing periods and measurements of weaned pups are summarized in Table 6.4b.

Interatoll Movement

Interatoll movement was documented for 34 seals that completed 59 movements between Midway Atoll and either Pearl and Hermes Reef or Kure Atoll (Tables 6.5a and b).

Factors Affecting Survival

Attacks by sharks, entanglement in marine debris, emaciation, and other/unknown causes led to 12 life-threatening conditions, which resulted in the confirmed death of 1 seal and the probable death of 4 other seals (Table 6.6). One very thin juvenile female was found dead of unknown causes on Eastern Island and 3 emaciated/very thin juveniles disappeared (2 of which displayed signs of ill health prior to death). One pup disappeared shortly after being born on Spit Island and was never seen again. Two seals were entangled in marine debris and were freed by researchers: a recently weaned female pup who had an eel trap cone around her muzzle and an adult female that became entangled in a line and trawl net. In addition to the incidents listed in table 6.6, 2 seals showed signs of ill health but later regained normal behavior patterns. In addition, 3 emaciated weaned pups were sighted in the fall, and 2 were not subsequently resighted.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service, Oceanic Society, and Midway Phoenix Corporation. Special thanks are extended Nancy Hoffman, Refuge Biologist; Stephanie Bennett and Joe Raffaele, USFWS Rangers; Wayne Sentman and Cynthia Vanderlip, OS staff; and the Midway Harbor crew. We also thank the officers and crew of the NOAA ship *Townsend Cromwell* for logistical assistance.

TABLES
for Midway Atoll

Table 6.1.--Summary statistics for atoll censuses (n = 25) of Hawaiian monk seals at Midway Atoll from March 7 to August 29, 2001.

Size/Sex	Mean number of individuals	Standard deviation
Adults	10.2	3.2
Male	2.0	1.2
Female	7.5	2.7
Unknown	0.6	1.3
Subadults	5.1	2.1
Male	2.3	1.3
Female	2.7	1.2
Unknown	0.2	0.4
Juveniles	3.4	2.3
Male	2.4	1.4
Female	0.9	1.1
Unknown	0.2	0.5
Pups	4.7	2.5
Male	2.7	1.7
Female	1.8	1.1
Unknown	0.3	0.5
Non-pup total	18.7	5.1
Grand total	23.4	4.9

Table 6.2.--Composition of the Hawaiian monk seal subpopulation at Midway Atoll during the spring and summer of 2001. Includes all known parturient females and pups born during the calendar year.

	Number of seals				
Size	Male	Female	Unknown	Total	Sex ratio male:female
Adults	10	23	0	33	0.4:1
Subadults	5	6	0	11	0.8:1
Juveniles	6	5	0	11	1.2:1
Pups	6	5	1	12	1.2:1
Non-pup total	21	34	0	55	0.6:1
Grand total	27	39	1	67	0.7:1

Table 6.3.--Summary of tagged known-age seals born at Midway Atoll and resighted at any location in 2001.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2001
1988	13	Male	0	NA
		Female	1	1
1989	12	Male	0	NA
		Female	0	NA
1990	11	Male	0	NA
		Female	0	NA
1991	10	Male	1	1
		Female	1	1
1992	9	Male	0	NA
		Female	1	1
1993	8	Male	1	0
		Female	0	NA
1994	7	Male	0	NA
		Female	0	NA
1995	6	Male	1	0
		Female	6	1
		Unknown	1	0
1996	5	Male	1	0
		Female	4	0
1997	4	Male	3	1
		Female	6	3
1998	3	Male	8	3
		Female	2	2
1999	2	Male	7	3
		Female	4	1
2000	1	Male	5	4
		Female	9	3

Table 6.4a.--Summary of Hawaiian monk seals born at Midway Atoll in 2001.

Event	Number of pups			
	Male	Female	Unk.	Total
Born	6	5	1	12
Probably died prior to weaning	0	0	1	1
Weaned	6	5	0	11
Tagged	6	5	0	11

Table 6.4b.--Summary of nursing periods and measurements of weaned pups at Midway Atoll in 2001. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	38.1	114.7	127.9
Standard deviation	3.6	7.8	4.7
n	11	11	11

Table 6.5a.–Documented movement of Hawaiian monk seals to Midway Atoll from other locations in 2001, summarized by movements between 2 locations. Four seals made more than 1 observed trip.

Destination	Number of trips, size, and sex class
Pearl and Hermes Reef	4 adult male 6 adult female 1 weaned pup male
Kure Atoll	3 adult male 12 adult female 2 subadult male 1 weaned pup male 1 weaned pup female

Table 6.5b.–Documented movement of Hawaiian monk seals from Midway Atoll to other locations in 2001, summarized by movements between 2 locations. Five seals made more than 1 observed trip.

Destination	Number of trips, size, and sex class
Pearl and Hermes Reef	2 adult male 6 adult female
Kure Atoll	3 adult male 13 adult female 2 subadult male 1 juvenile male 1 weaned pup male 1 weaned pup female

Table 6.6.--Factors affecting Hawaiian monk seal survival at Midway Atoll in 2001.

Size	Sex	Total	Outcome		
			Injured	Died	Probably died
Attack by Large Shark					
Adult	Female	2	2	0	0
Juvenile	Male	2	2	0	0
Mounting by Males (none observed)					
Entanglement					
Adult	Female	1[a]	0	0	0
Weaned pup	Female	1[a]	0	0	0
Emaciation					
Juvenile	Male	1	0	0	1
	Female	3	0	1[b]	2[c]
Other/Unknown					
Subadult	Female	1	1	0	0
Nursing pup	Unknown	1	0	0	1

[a]Seal released by researchers.

[b]Seal was also considered ill, found dead on Eastern, necropsy completed, cause of death unknown.

[c]One of the females was also considered ill, became thin, began displaying unusual behaviors, then was never seen again.

CHAPTER 7. THE HAWAIIAN MONK SEAL ON KURE ATOLL, 2001

Patti A. Haase and Albert L. Harting

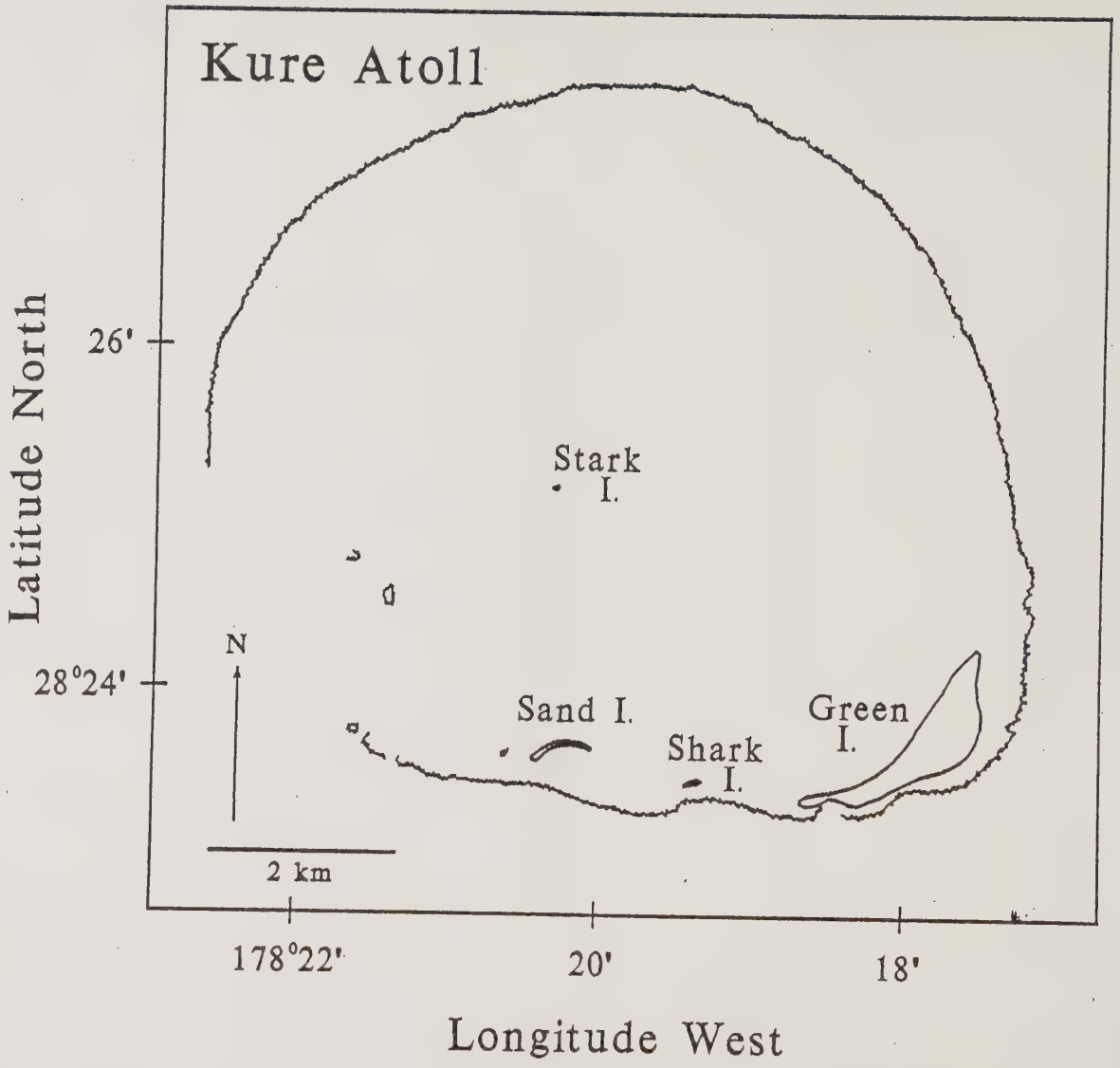

Fig. 7.1 Kure Atoll in the Northwestern Hawaiian Islands.

Kure Atoll (lat. 28°25'N, long. 178°10'W) is one of the primary haulout and pupping locations of the Hawaiian monk seal. The atoll is located ca. 2,300 km northwest of Oahu in the Northwestern Hawaiian Islands (Fig. 1.1) and is a seabird sanctuary of the State of Hawaii. The atoll consists of a circular barrier reef approximately 9 km in diameter, the enclosed lagoon, 1 permanent vegetated island (Green Island), 2 sand islets (Sand and Shark), and an ephemerally emergent area known locally as Stark Reef (Fig. 7.1). From 1960 to 1992, Green Island was the site of a U.S. Coast Guard (USCG) LORAN station, staffed by 20-30 USCG personnel. In July 1992, this station was closed and vacated by the USCG, leaving the atoll uninhabited. In 1993, the USCG completed the removal of most of the infrastructure on Green Island.

The Kure Atoll subpopulation of Hawaiian monk seals has increased in recent years due, apparently in part, to a reduction of human disturbance and a capture and release program designed to increase recruitment of females. The Rehabilitation Project (1984-91, 1993-95) involved the capture of undersized weaned female pups from French Frigate Shoals, their rehabilitation on Oahu, and subsequent transport to Kure Atoll for release.

RESEARCH

National Marine Fisheries Service (NMFS) began research on the Hawaiian monk seal at Kure Atoll in 1981. In 2001, research was conducted by NMFS on April 11, from May 18 to July 18, and from October 30 to November 13. The perimeter of Green Island was divided into 8 sectors using artificial or natural landmarks. Research objectives specific to this subpopulation in 2001 included (1) identification of all seals using the atoll, and (2) assessing entanglement risks and other negative impacts following the *Paradise Queen II*'s grounding at Kure Atoll on October 16, 1998.

Censuses and Patrols

Atoll censuses (n = 12) were conducted every fourth day on average, from May 25 to July 10. Each census began between 1237 and 1350 and ended between 1527 and 1755 Hawaii Standard Time. All islets were censused on foot by 1 or 2 persons. Shark Islet and Stark Reef were not emergent during the 2001 field season. Patrols were conducted on nonatoll census days to identify seals and monitor locations used by parturient females. In total, 15 patrols of Green Island and 1 patrol of Sand Islet were conducted.

Individual Identification

A total of 127 individuals (107, excluding pups) were identified by existing or applied tags, bleach marks, scars, or natural markings. All weaned pups (n = 17) were

tagged with Temple Tags, and passive integrated transponder (PIT) tags. One female pup was still nursing at the end of the field season and was not resighted during the autumn camp, so she was not tagged. Three seals (an adult male, a juvenile female, and a known-age juvenile male born at Kure in 1998) were newly tagged with Temple Tags, and the juvenile female also received a PIT tag. In addition, 4 adult seals (3 males and a female) were retagged with Temple Tags in 2001.

Collection of Samples

Sixteen scat samples were collected. Skin punches were collected from 18 seals during tagging. Various epidemiological samples were collected from 2 seals during the health and disease study in May, and from 24 seals during the satellite tagging project in October and November. In total, 299 items of potentially entangling marine debris were inventoried. Two large net aggregates remain partially buried on Green Island on the southeast side. The remainder of inventoried debris items were destroyed before the end of the field season or securely stored for later removal.

Special Studies

Foraging Ecology, Health, and Disease

Under provisions of the Marine Mammal Protection Act of 1972, the Working Group on Marine Mammal Unusual Mortality Events (UME) determined that a UME involving juvenile Hawaiian monk seals was occurring at Laysan (see the Laysan Island chapter). A team visited Kure Atoll on May 18 and collected blood, fecal samples, virological and bacteriological swabs, and blubber biopsies from 2 healthy juveniles (1 male and 1 female).

During October-November 2001, a field camp was deployed (1) to attach satellite-linked dive recorders (SLDRs) in order to characterize at-sea habitat use, (2) to collect epidemiological sampled (blood, swabs, blubber, etc.) for health and disease assessment, and (3) to retag or newly tag seals to facilitate individual identification in the subpopulation. A total of 27 seals were handled. Twenty-four seals were fully sampled for the health and disease assessment and received SLDRs.

Noteworthy Events

Impacts of *Paradise Queen II* Grounding

On October 16, 1998, the *Paradise Queen II,* a lobster fishing vessel, ran aground on the eastern edge of Kure Atoll. In 2000, a large portion of the hull remained in the water on the reef, but remnants of the wheelhouse and 1 other structural piece had washed ashore on the eastern side of Green Island. In 2001, the wheelhouse remained on the

eastern side of the island, and 1 other structural piece rested on the beach on the western side (sector 1). The large portion of main deck which originally migrated around the island from the west side (sector 1; in 1999) to the southwest point (sector 6; in 2000) was not seen in 2001. Almost all previously collected traps were removed from Green Island during a multiagency cleanup effort in October 2000, and only 15 traps were collected in 2001. A few of these were destroyed but the majority remain stored on the island. Some of the lead (used to weigh traps) still remain on the island. It is unknown whether any lobster traps remain in the waters off Kure Atoll.

RESULTS

Subpopulation Abundance and Composition

The mean (±SD) of 12 atoll censuses was 53.4 seals (±9.2) including pups, and 45.2 seals (±6.7) excluding pups (Table 7.1). The total spring-summer subpopulation was 118 individuals, 100 excluding pups (Table 7.2). This number is a subset of the total identified in the calendar year. The numbers of tagged known-age seals born at Kure Atoll during the period from 1981 to 2000, and resighted at any location in 2001, are summarized in Table 7.3.

Reproduction

At least 18 pups were born at Kure Atoll in 2001, and 17 successfully weaned (Table 7.4a). One pup was still nursing at the end of the study period. Nursing periods and measurements of weaned pups are summarized in Table 7.4b.) The birth rate, measured as the number of pups born divided by the number of adult-sized females in the subpopulation X 100 was 45.0% (18/40) X 100). Nine of 10 identified parturient females (90.0%) were involved in past management efforts; 6 had been temporarily maintained as pups in the Kure Atoll Head Start enclosure (1 each in 1984 and 1991, and 2 each in 1985 and 1988), and 3 were rehabilitated seals from FFS introduced to Kure as yearlings via the Head Start enclosure (1 each released in 1990, 1993, and 1995).

Interatoll Movement

Interatoll movement was documented for 25 seals that completed a total of 44 movements between Kure Atoll and either Lisianski, Pearl and Hermes Reef, or Midway Atoll (Table 7.5a and b).

Factors Affecting Survival

Attacks by large sharks and entanglement in marine debris led to 3 life-threatening conditions. An adult female and a male weaned pup were injured by a large

shark. Another male weaned pup became entangled and was subsequently released by observers. No dead seals were observed during 2001 (Table 7.6).

ACKNOWLEDGMENTS

We acknowledge the support of the State of Hawaii, Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DoFAW), and Leo Milan for assistance at Kure Atoll. We also thank the captain and crew of the NOAA ship *Townsend Cromwell* for logistical support and transport to and from the island.

TABLES
for Kure Atoll

Table 7.1.–Summary statistics for atoll censuses (n = 12) of Hawaiian monk seals at Kure Atoll from May 25 to July 10, 2001.

Size/Sex	Mean number of individuals	Standard deviation
Adults	35.3	5.1
Male	13.3	3.4
Female	17.8	4.0
Unknown	4.2	2.7
Subadults	6.5	2.5
Male	3.4	1.5
Female	2.2	0.8
Unknown	0.9	1.0
Juveniles	3.4	1.4
Male	1.6	0.9
Female	1.7	0.9
Unknown	0.2	0.4
Pups	8.3	3.6
Male	1.2	1.1
Female	4.4	2.0
Unknown	2.7	2.7
Non-pup total	45.2	6.7
Grand total	53.4	9.2

Table 7.2.–Composition of the Hawaiian monk seal subpopulation at Kure Atoll during the spring and summer of 2001. Includes all known parturient females and pups born during the calendar year.

	Number of seals			
Size	Male	Female	Total	Sex ratio male:female
Adults	32	40[a]	72	0.8:1
Subadults	10	6	16	1.7:1
Juveniles	6	6	12	1.0:1
Pups	4	14	18[b]	0.3:1
Non-pup total	48	52	100	0.9:1
Grand total	52	66	118	0.8:1

[a] Number includes 25 individuals involved in management programs (Head Start, Rehabilitation, and Translocation).

[b] Number includes 4 prematurely weaned female pups and 1 prematurely weaned male pup.

Table 7.3.–Summary of tagged known-age seals born at Kure Atoll and resighted at any location in 2001.

Cohort year	Age (years)	Sex	Number originally tagged	Number resighted in 2001
1981	20	Male	3	2
		Female	5	0
1982	19	Male	1	0
		Female	3	2
1983	18	Male	4	3
		Female	0	NA
1984	17	Male	4	0
		Female	2	2
1985	16	Male	2	1
		Female	3	2
1986	15	Male	1	0
		Female	0	NA
1987	14	Male	1	1
		Female	3	3[a]
1988	13	Male	2	2
		Female	5	2
1989	12	Male	5	1
		Female	4	1
1990	11	Male	3	0
		Female	3	1
1991	10	Male	7	4
		Female	6	3[a]
1992	9	Male	5	3
		Female	8	5
1993	8	Male	9	5
		Female	4	2
1994	7	Male	3	0
		Female	0	NA
1995	6	Male	6	4
		Female	5	2
1996	5	Male	10	4
		Female	6	0
1997	4	Male	9	1
		Female	7	3
1998	3	Male	17	7
		Female	6	3
1999	2	Male	8	2
		Female	13	6
2000	1	Male	5	2
		Female	8	0

[a] Cohort survivors include seals removed from Kure Atoll for rehabilitation. These seals ($n = 2$) were released at Kure or Midway Atoll.

Table 7.4a.–Summary of Hawaiian monk seals born at Kure Atoll in 2001.

Event	Number of pups		
	Male	Female	Total
Born	4	14	18
Died prior to weaning	0	0	0
Still nursing	0	1	1
Weaned	4	13	17[a]
Tagged	4	13	17

[a] Number includes 4 prematurely weaned female pups and 1 prematurely weaned male pup.

Table 7.4b.–Summary of nursing periods and measurements of weaned pups at Kure Atoll in 2001. Nursing periods were calculated where birth and weaning dates were both known or occurred within a range of 4 days or less. All measurements were taken within 2 weeks after weaning.

	Nursing period (d)	Axillary girth (cm)	Straight dorsal length (cm)
Mean	33.0	111.2	128.3
Standard deviation	--	6.8	3.6
n	1	5	5

Table 7.5a.–Documented movement of Hawaiian monk seals to Kure Atoll from other locations in 2001, summarized by movements between 2 locations. Five seals made more than 1 observed trip.

Original location	Number of trips, size, and sex class
Lisianski Island	1 subadult male
Pearl and Hermes Reef	1 adult female 1 subadult male
Midway Atoll	3 adult male 13 adult female 2 subadult male 1 juvenile male 1 male weaned pup 1 female weaned pup

Table 7.5b.–Documented movement of Hawaiian monk seals from Kure Atoll to other locations in 2001, summarized by movements between 2 locations. Three seals made more than 1 observed trip.

Destination	Number of trips, size, and sex class
Pearl and Hermes Reef	1 adult female
Midway Atoll	3 adult male 12 adult female 2 subadult male 1 male weaned pup 1 female weaned pup

Table 7.6.–Factors affecting Hawaiian monk seal survival at Kure Atoll in 2001.

			Outcome		
Size	Sex	Total	Injured	Died	Probably died
Attack by Large Shark					
Adult	Female	1	1	0	0
Weaned pup	Male	1	1	0	0
Mounting by Males					
(none observed)					
Entanglement					
Weaned pup	Male	1[a]	1	0	0

[a] Seal was released by observers.

CHAPTER 8. THE HAWAIIAN MONK SEAL ON NIHOA AND NECKER ISLANDS, GARDNER PINNACLES, AND MARO REEF, 2001

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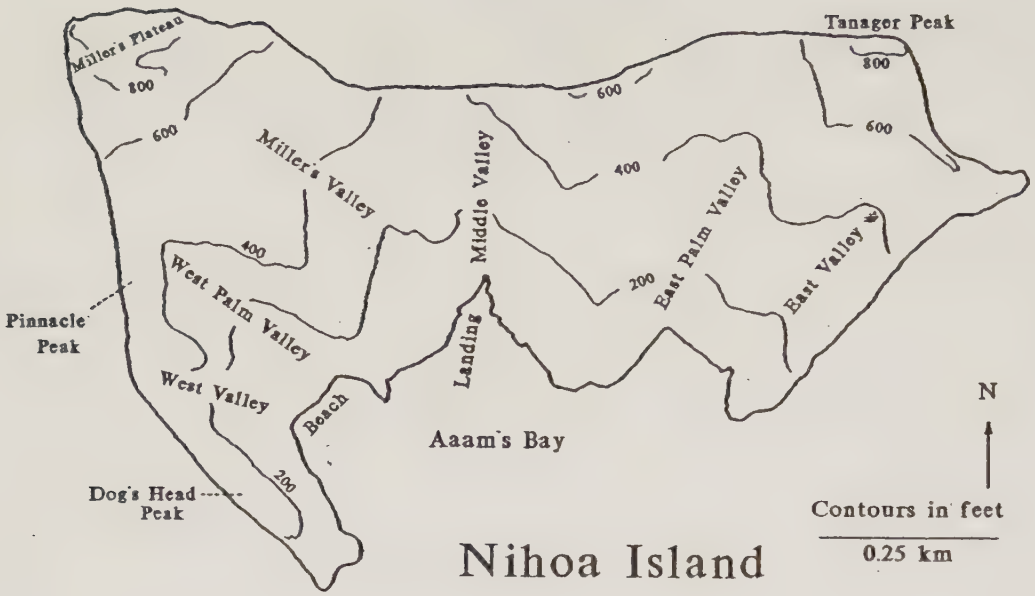

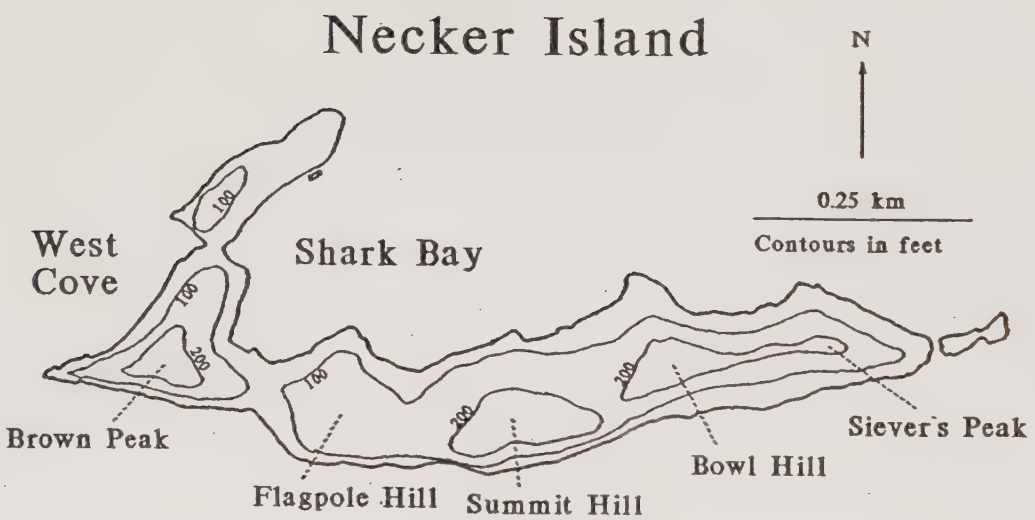

Fig. 8.1 Nihoa and Necker Islands in the Northwestern Hawaiian Islands.

Nihoa Island (lat. 23°04'N, long. 161°55'W), Necker Island (lat. 23°36'N, long. 164°42'W), Gardner Pinnacles (lat. 25°00'N, long. 167°55'W), and Maro Reef (lat. 25°25'N, long. 170°35'W) are located in the Northwestern Hawaiian Islands (Fig. 1.1) and lie within the Hawaiian Islands National Wildlife Refuge.

RESEARCH

In 2001, the National Marine Fisheries Service collected data at Nihoa Island on July 31, at Necker Island on July 30, and at Gardner Pinnacles on July 28. Additional data were collected by U.S. Fish and Wildlife Service personnel at Nihoa Island on August 30, at Necker Island on September 1-2, at Gardner Pinnacles on September 7, and at Maro Reef on August 20. The perimeters of Nihoa and Necker Islands were divided into 3 and 10 sectors, respectively, using natural landmarks (Fig. 8.1). Gardner Pinnacles was considered one sector. In 2001, research objectives specific to Nihoa and Necker Islands, and Gardner Pinnacles included assessment of pup production and the extent of migration between French Frigate Shoals and these locations.

Censuses and Patrols

Due to rough seas, a beach count was not conducted on Nihoa Island on July 31. However, a boat survey from the NOAA ship *Townsend Cromwell* was conducted along the south facing shore of the island beginning at 1033 Hawaii Standard Time and continuing for approximately 30 minutes. A beach count was conducted by 1 observer on August 30, beginning at 0923 Hawaii Standard Time and continuing for 5.8 h.

Three beach counts were conducted on Necker Island on July 30 and on September 1-2 by 2 and 1 observers, respectively. Censuses began between 0732 and 0820 Hawaii Standard Time and continued for 3.5 - 5.5 h. No boat surveys were conducted.

Two boat surveys were conducted at Gardner Pinnacles on July 28 and September 7 by 2 and 1 observers, respectively. Censuses began between 1023 and 1347 Hawaii Standard Time and continued for approximately 0.75 h.

No surveys were conducted at Maro Reef. However, incidental seal sightings were noted by USFWS personnel on August 20.

Individual Identification

On Nihoa Island, none of the seals sighted were identifiable by natural markings, scars, or tags during either of the surveys.

On July 30, an adult female with broken French Frigate Shoals tags was seen on Necker Island. The tags indicate the seal was 15 years old but further identification was not possible. No other seals appeared tagged. During September 1-2, at least 3 adult seals (unknown sex) were noted with French Frigate Shoals tags; no further identification was possible.

On July 28, an adult male was noted with a French Frigate Shoals tag at Gardner Pinnacles. No further identification was possible. During September 7, none of the seals seen were identified.

On Maro Reef, 1 Laysan tagged weaned pup was sighted and identified.

Collection of Samples

No samples were collected at Nihoa Island, Necker Island, Gardner Pinnacles, or Maro Reef in 2001.

RESULTS

Subpopulation Abundance and Composition

One partial island count at Nihoa Island on July 31 noted 3 seals (no pups observed). The census total for complete count conducted on Nihoa Island was 9 seals (no pups observed) on August 30. Because of limited effort, the composition of the spring-summer subpopulation was not determined.

The census totals for 3 counts conducted on Necker Island were 11 seals (10 excluding pups) on July 30, 13 seals (12 excluding pups) on September 1, and 22 seals (20 excluding pups) on September 2. The mean of these counts is 15.3 ($\pm$ 5.9 SD) including pups and 14.0 ($\pm$ 5.3 SD) excluding pups. Because of limited effort, the composition of the spring-summer subpopulation was not determined.

The census totals for 2 counts conducted at Gardner Pinnacles were 5 seals (no pups observed) on July 28 and 3 seals (no pups observed) on September 7. Because of the limited effort, the composition of the spring-summer subpopulation was not determined.

No census totals were calculated for Maro Reef since the seal sighting was incidental to other USFWS objectives.

Reproduction

No pups were observed at Nihoa in 2001. At least 3 pups were born at Necker in 2001; 1 female pup was successfully weaned, and 2 were still nursing (both of unknown sex). No pups were observed at Gardner Pinnacles in 2001. One weaned pup was observed at Maro Reef in 2001, but this tagged pup was born at Laysan.

Interatoll Movement

Interatoll movement was documented for 2 seals; a weaned male pup, born and tagged at Laysan Island in 2001 was subsequently observed at Maro Reef and an adult female identified at Necker Island in 2000 was observed at French Frigate Shoals in 2001. The interatoll movement of tagged seals observed at Necker Island and Gardner Pinnacles in 2001 could not be determined since these seals were unidentified. Interatoll movement was not documented for seals observed at Nihoa Island or Gardner Pinnacles.

Factors Affecting Survival

Unknown factors led to at least 1 life-threatening condition at Necker Island that resulted in the confirmed death of 1 animal: a dead adult seal, sex unknown, observed on July 30. In addition, an adult female was observed with a dorsal mounting injury of unknown severity in September 2001. No factors affecting survival were observed on Nihoa Island, Gardner Pinnacles, or Maro Reef in 2001.

ACKNOWLEDGMENTS

We acknowledge the support of the U.S. Fish and Wildlife Service; Hawaiian Islands National Wildlife Refuge staff; and the captain, officers, and crew of the NOAA ship *Townsend Cromwell* for logistical assistance. We also thank USFWS personnel for collecting seal counts at these sites in August and September.

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1984. Hawaiian monk seal population research, Lisianski Island, 1982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-47, 33 p.
Winchell, J.
1990. Field manual for phocid necropsies (specifically *Monachus schauinslandi*). U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-146, 55 p.
Yochem, P. K., R. C. Braun, B. R. Ryon, J. D. Baker, and G. A. Antonelis.
2003. Contingency plan for Hawaiian monk seal unusual mortality events. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-PIFSC-1, 147 p.

APPENDIXES

Appendix A.--Reports summarizing annual field research on the Hawaiian monk seal by the National Marine Fisheries Service and collaborating scientists.

All islands

Johanos, T. C., and J. D. Baker (Eds.).
2002. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 2000. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-340, 125 p.

Johanos, T. C., and J. D. Baker (Eds.).
2001. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1999. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-310, 130 p.

Johanos, T. C., and J. D. Baker (Eds.).
2000. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1998. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-292, 125 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1999. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1997. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-262, 131 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1999. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1996. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-259, 134 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1997. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1995. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-241, 121 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1996. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1993. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-227, 141 p.

Johanos, T. C., and T. J. Ragen (Eds.).
1996. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1994. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-229, 111 p.

Appendix A.--Continued.

Johanos, T. C., L. M. Hiruki, and T. J. Ragen (Eds.).
1995. The Hawaiian monk seal in the Northwestern Hawaiian Islands, 1992. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-216, 128 p.

French Frigate Shoals

Craig, M. P., J. L. Megyesi, C. S. Hall, J. L. Glueck, L. P. Laniawe, E. A. Delaney, S. S. Keefer,
M. A. McDermond, M. S. Schulz, G. L. Nakai, B. L. Becker, L. M. Hiruki, and R. J. Morrow.
1994. The Hawaiian monk seal at French Frigate Shoals, 1990-91. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-210, 70 p.

Craig, M. P., D. J. Alcorn, R. G. Forsyth, T. Gerrodette, M. A. Brown, B. K. Choy, L. Dean, L. M.
Dennlinger, L. E. Gill, S. S. Keefer, M. M. Lee, J. S. Lennox, C. R. Lorence, G. L. Nakai, and
K. R. Niethammer.
1992. The Hawaiian monk seal at French Frigate Shoals, 1988-89. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-178, 83 p.

Eliason, J. J., J. R. Henderson, and M. A. Webber.
1993. Hawaiian monk seal observations at French Frigate Shoals, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-187, 46 p.

Eliason, J. J., and J. R. Henderson.
1992. Hawaiian monk seal observations at French Frigate Shoals, 1984. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-177, 61 p.

Fairaizl, G. W.
1984. Intra-atoll resighting of the Hawaiian monk seal, *Monachus schauinslandi*, at French Frigate Shoals, 1 January 1983-31 August 1983. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish Serv., NOAA, Honolulu, HI 96822-2396. Southwest Fish. Cent. Admin. Rep. H-84-5C, 27 p.

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1984. Hawaiian monk seal observations on French Frigate Shoals, 1980. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-50, 47 p.

Appendix A.--Continued.

Laysan Island

Alcorn, D.
1984. The Hawaiian monk seal on Laysan Island: 1982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-42, 37 p.

Alcorn, D. J., and E. K. Buelna.
1989. The Hawaiian monk seal on Laysan Island, 1983. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-124, 46 p.

Alcorn, D. J., and R. L. Westlake.
1993. The Hawaiian monk seal on Laysan Island, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-191, 25 p.

Becker, B. L., P. A. Ching, L. M. Hiruki, and S. A. Zur.
1994. The Hawaiian monk seal on Laysan Island, 1987 and 1989. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-213, 20 p.

Becker, B. L., R. J. Morrow, and J. K. Leialoha.
1989. Censuses and interatoll movements of the Hawaiian monk seal on Laysan Island, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-135, 25 p.

Becker, B. L., K. E. O'Brien, K. B. Lombard, and L. P. Laniawe.
1995. The Hawaiian monk seal on Laysan Island, 1991. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-214, 16 p.

Johanos, T. C., and S. L. Austin.
1988. Hawaiian monk seal population structure, reproduction, and survival on Laysan Island, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-118, 38 p.

Johanos, T. C., B. L. Becker, M. A. Brown, B. K. Choy, L. M. Hiruki, R. E. Brainard, and R. L. Westlake
1990. The Hawaiian monk seal on Laysan Island, 1988. U.S.Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-151, 24 p.

Johanos, T. C., A. K. H. Kam, and R. G. Forsyth.
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Appendix A.--Continued.

Johnson, B. W., and P. A. Johnson.
1984. Observations of the Hawaiian monk seal on Laysan Island from 1977 through 1980. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-49, 65 p.

Lombard, K. B., B. L. Becker, M. P. Craig, G. C. Spencer, and K. Hague-Bechard.
1994. The Hawaiian monk seal on Laysan Island, 1990. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-206, 16 p.

Lisianski Island

Alcorn, D. J., R. G. Forsyth, and R. L. Westlake.
1988. Hawaiian monk seal research on Lisianski Island, 1984 and 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-120, 22 p.

Johanos, T. C., and J. R. Henderson.
1986. Hawaiian monk seal reproduction and injuries on Lisianski Island, 1982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-64, 7 p.

Johanos, T. C., and A. K. H. Kam.
1986. The Hawaiian monk seal on Lisianski Island: 1983. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-58, 37 p.

Johanos, T. C., and R. P. Withrow.
1988. Hawaiian monk seal and green turtle research on Lisianski Island, 1987. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-121, 18 p.

Lee, M. M., L. K. Timme, R. Van Toorenburg, and B. L. Becker.
1993. The Hawaiian monk seal on Lisianski Island, 1988 and 1990. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-179, 33 p.

Stone, H. S.
1984. Hawaiian monk seal population research, Lisianski Island, 1982. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-47, 33 p.

Westlake, R. L., and P. J. Siepmann.
1988. Hawaiian monk seal and green turtle research on Lisianski Island, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-119, 18 p.

Appendix A.--Continued.

Pearl and Hermes Reef

Choy, B. K., and L. M. Hiruki.
1992. The Hawaiian monk seal and green turtle on Pearl and Hermes Reef, 1988. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-175, 18 p.

Finn, M. A., J. R. Henderson, B. L. Becker, and T. J. Ragen.
1993. The Hawaiian monk seal and green turtle at Pearl and Hermes Reef, 1990 and 1991. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-182, 29 p.

Forsyth, R. G., D. J. Alcorn, T. Gerrodette, and W. G. Gilmartin.
1988. The Hawaiian monk seal and green turtle on Pearl and Hermes Reef, 1986. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-107, 24 p.

Kure Atoll

Bowlby, C. E., P. Scoggins, R. Watson, and M. Reddy.
1991. The Hawaiian monk seal, *Monachus schauinslandi*, at Kure Atoll, 1982-83. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-155, 28 p.

Gilmartin, W. G., R. J. Morrow, and A. M. Houtman.
1986. Hawaiian monk seal observations and captive maintenance project at Kure Atoll, 1981. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-59, 9 p.

Henderson, J. R., and M. R. Finnegan
1990. Population monitoring of the Hawaiian monk seal, *Monachus schauinslandi*, and captive maintenance project at Kure Atoll, 1988. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-150, 24 p.

Reddy, M. L.
1989. Population monitoring of the Hawaiian monk seal, *Monachus schauinslandi*, and captive maintenance project for female pups at Kure Atoll, 1987. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-123, 37 p.

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Reddy, M. L., and C. A. Griffith.
1988. Hawaiian monk seal population monitoring, pup captive maintenance program, and incidental observations of the green turtle at Kure Atoll, 1985. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-101, 35 p.

Van Toorenburg, R. A., W. G. Gilmartin, and J. R. Henderson.
1993. Composition of the Hawaiian monk seal population at Kure Atoll, 1990. Pac. Sci. 47(3):211-214.

Nihoa and Necker Islands

Conant, S.
1985. Observations of Hawaiian monk seals on Necker Island, Northwestern Hawaiian Islands. 'Elepaio. 6(2):11-12.

Finn, M. A. and M. A. Rice.
1994. Hawaiian monk seal observations at Necker Island, 1993. 'Elepaio. 55(9):55-58.

Morrow, R. J., and E. K. Buelna.
1985. The Hawaiian monk seal and green turtle on Necker Island, 1983. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-55, 11 p.

Appendix B.--Hawaiian monk seal census form and 2001 census form directions.

(See following pages.)

SEAL CENSUS FORM

ENTERED ☐

TYPE _____ COMPUTER PAGE NO. ☐☐☐☐ PAGE _____ OF _____

ID _____ OBSERVER ☐☐☐ TIME BEGIN ☐☐☐☐ END ☐☐☐☐

_____ NUMBER _____ TEMP. ☐☐ WIND ☐☐☐ CLOUD ☐☐ Prec. ☐

Time	Sector	Size	Sex	Beach Pos	Condition	ID			TAG				MOLT		Disturb	ASSOCIATION			Notes	Notes	EVENT	
						T/P	No.	?	No.	L/R	Col	?	%	?		Line No.	Dist	Behavior			Type	Codes

Line No.	Continue	Time	Sector	Size	Sex	Beach Pos	Condition	ID			TAG				MOLT		Disturb	ASSOCIATION			Notes	Notes	EVENT	
								T/P	No.	?	No.	L/R	Col	?	%	?		Line No.	Dist	Behavior			Type	Codes
15																								
16																								
17																								
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NOTES:

2001
CENSUS FORM DIRECTIONS
(Unabridged - Laysan and Lisianski Islands)

This form is used to record all Hawaiian monk seal and green turtle sightings. Turtle sightings are recorded only during census activities (not during patrols), unless noteworthy event occurs (turtle injured, tagged, tumored, mating, etc.). On the census form, all data that can be recorded for seals can also be recorded for turtles (although this data may not be required). **At French Frigate Shoals, do not record a data line for each turtle sighting; instead, write the total for each size/sex class at the bottom of the page.**

All original data should be coded in pencil. Never erase data once you have left the recording site. Instead, cross errors out with a single line. Field editing is editing before running the data entry and checking program. All field editing by the data collector should be in blue, and field editing by others should be in red. As soon as you begin the entry and checking program, the computer will assign the computer page number and display it on the screen. At this point, be sure to fill it in on your census form. All editing after this point should be in orange. After completing the entry and checking program, check off and initial the ENTERED box on the census form.

A separate data sheet should be filled out for each date, observer, data type, and island within an atoll. If no seals are present, you should still fill out the information at the top of the census form and write "No seals" in the data area (only enter the header information). If the island itself is not present, indicate this by using 99 for the sector code, leaving the rest of the (first) line blank. To save paper, you should use a census form with multiple headers if you only have a few seals to record (i.e., at some islands within an atoll, or when recording incidental sightings before or after census or patrol). In essence, on a census form with multiple headers, each header and its associated lines represents a separate data sheet.

If two people conduct the census, they should have the same weather and the same begin and end time (i.e., both begin at the same time and place, and proceed in opposite directions until they meet on the other side of the island or islet) and combine pages into one set. Patrols may be conducted by more than one observer, but page sets are not combined, and header information may differ between page sets. Patrol observers should attempt to start at roughly the same time. The sum of all observers' patrol activity for a day should result in one complete island count.

Always record disturbance. You must be honest about this! Fill out a census form to document disturbance if you disturb a seal when you are not otherwise collecting data. On a census or atoll count, it is also assumed that condition and molt data will be taken.

Do not make up additional codes. If the need for an additional code arises, contact Honolulu.

AGE HEADER

DATA TYPE

C =Census: A complete, timed count on an island begun around 1300. Census is conducted as quickly as possible (while gathering all information). Data collected on all seals and turtles.

A =

Atoll-wide census (must be completed within 2 consecutive days). Data collected on all seals and turtles.

B =

Behavior patrol: A complete, untimed count where size, sex, ID and disturbance are recorded. Associations are assumed to be coded for all seals (In 2001, collect only at Laysan and Lisianski Islands, code behaviors for all Adult/S4 seals and their associated seals, otherwise code behavior X (data not taken). Record turtles only if noteworthy observation.

P =

Patrol: A complete, untimed count where size, sex, ID and disturbance are recorded. Behavior data is not taken. Record turtles only if noteworthy observation.

I =

Incidental observation. In this data type, null fields are interpreted as "data not recorded", so code data explicitly. If numbered, this indicates a full island incidental with year-specific goals. At Laysan and Lisianski Islands in 2001, these surveys will record mother-pup pairs, weaned pups, molters, survival factors, major behavioral events (i.e., severe harassments and mobbings) and other noteworthy observations.

T =

Tag status entry for non-active tags (tags not currently on a seal). Record tag status (F or R) in notes columns.

COMPUTER PAGE NO.

Leave this blank during data collection. It will be assigned and displayed on the screen when you enter the data. At that time, be sure to fill in the computer page number on your census form, as this number is needed for data retrieval.

PAGE Page number within a census or patrol. For example, if the census (or patrol) requires three pages, then mark the first page as "page 1 of 3" and so on. If more than 1 person conducts the census, then combine page numbers; person A has pages 1 and 2, while person B has pages 3 and 4 of a four-page census day. The maximum number of pages in a set is 9. Header information (time begin/end, date, number, and weather) should be the same for all pages within a set.

ISLAND Name of island and atoll, e.g., East, FFS.

OBSERVER

Three initials. If no middle initial, use the first and last block.

TIME BEGIN and **END**

On a 24-h clock, e.g., 6 p.m. = 1800, for the group of pages. Midway uses Midway time, all other sites use Hawaii Standard time.

DATE The date that data are collected (in YYYYMMDD format).

NUMBER Censuses, Atoll counts, Behavior patrols, and Patrols must be numbered. Each data type will have its own 3 digit number series, starting with 001. For data types other than **A**, have a separate number series for each islet within an atoll.

Weather information (except temperature) should be a summary of the entire day up until the end of the census or patrol, not merely an instantaneous observation. Temperatures taken in the morning are not representative for the period of data collection.

TEMP. Temperature in degrees Celsius at beginning of census or patrol.

WIND Speed:0 = no wind, calm (<5 knots)
1 = light breeze (5-15 knots)
2 = strong wind (>15 knots)
Direction:NN,NE,EE,SE,SS,SW,WW,NW
Thus, 2 N N = strong wind from north

CLOUD Cloud cover: 00 = no clouds
01-09 = 10 to 90% cover
10 = 100% cover

PREC. Precipitation: 0 = no precipitation or trace
1 = mist/drizzle
2 = rain
3 = intermittent rain

LINES

CONTINUE If the same seal sighting is recorded on several lines for any reason (e.g., additional tag or association, behavior at a later time, change of beach position), put the original line number you are continuing from here. Lines may be continued only within the same page. Fill in the original line as completely as possible. During entry, the data in all fields from TIME through MOLT must be copied from the original line if left blank on the continuation line. Several lines can have the same continuation line number.

Make a new original line (i.e. do not use continuation lines) for a seal each time that you come abreast of it on census or patrol.

TIME The time should be recorded for each seal sighting, on a 24-h clock

SECTOR Location on island (e.g., 1-20 on Laysan)
Special codes as follows:
00 = unknown sector
77 = pen
88 = offshore spit/emergent reef
99 = island not present

SIZE Size is estimated using a classification scheme from Stone (1984), using the following terminology. Note that seals are "sized" by length, girth, appearance, and reproductive status, not by age (except pups):

Pup	Seals born within the calendar year. Newborn pups are black, and weight ca. 11 to 15 kg. Pups molt to a silver-gray pelage near weaning. Weaning weight is ca. 50 to 80 kg.
Juvenile	Short, slight seals from the length of a weaned pup (about 138 cm) to 20-30 cm longer; includes yearlings, and other young seals up to 3 years. Distinguished from pups by thinness and yellowish color.
Subadults	Seals perceptibly longer than juveniles up to breeding size; less robust than adults, generally with lighter pelage. Immature seals ca. 3 to 5 or 6 years old.
Adult	Reproductively active or breeding size seals at least as long as known breeders. Mature or probably mature seals. Adult females often have extensive back scars or wounds; adult males usually dark, including ventrum, and extensively scarred.

Code size as follows:

Pups of the year

P0 = Fetus (aborted, clearly pre-term pup)

P = Nursing pup

- P1 = Nursing pup, wrinkles
- P2 = Nursing pup, no wrinkles
- P3 = Nursing pup, blimp, black
- P4 = Nursing pup, molting
- P5 = Nursing pup, molted

PW = Prematurely weaned/undersized weaned pup (weaned ≤ 2 wks ago and < 90cm girth). Code as PW at time of weaning, and then can code as W for remainder of season.

W = Weaned pup

Immatures

I = Immature

- J = Juvenile
  - J1 = Juvenile I
  - J2 = Juvenile II
- S = Subadult
  - S3 = Subadult III
  - S4 = Subadult IV

Adults

A = Adult

Unknowns

U = Seal of unknown size

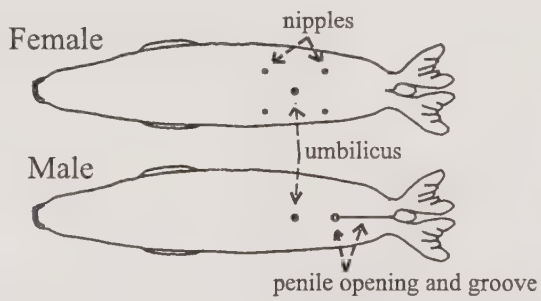
Turtles

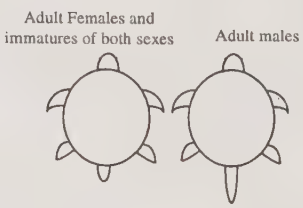
T = Turtle (lengths from anterior to posterior tip of carapace)

- T1 = Turtle, juvenile (<65 cm straight carapace length)
- T2 = Turtle, subadult (65 - 80 cm)
- T3 = Turtle, adult (>80 cm)

Only code a seal's sex as known if the ventral is seen, even if you "know" the sex because of the tag, bleach, scars, or behavior. The only exception is that the mother in a mother/pup pair should be recorded as a female. The sex of a turtle can only be distinguished externally if it is adult-sized.

SEX M = Male
F = Female
U = Unknown





BEACH POS. Location of seal or turtle when observer comes abreast of animal (e.g., if seal is seen in the water from a distance and yet is on the beach when the observer come abreast, the seal is recorded as being on the beach). When recording interactions (at Laysan and Lisianski Islands in 2000), record behaviors as you see them ahead of you (within 30 m). When you come abreast of the seal, record the beach position and time and make this your original line. All previously recorded lines for this sighting will be reverse continuation lines.

0 = animal floating or swimming in water (not included in census tally but may be used for behavioral data or other analysis).
1 = on the beach (or regularly surveyed areas on the fringing reef for **Midway Reef Surveys**)
9 = on an offshore rock/reef with no connections to the island. Separated from shore by a deep channel or substantial distance, and not regularly surveyed (not included in census tally). For **Midway Reef Surveys**, use beach position **9** for the back side of the reef and other areas that are not regularly surveyed.
X = data not taken

CONDITION Condition is recorded for all seals (except nursing pups) on census or atoll count. **Always record** the condition of the mom on her first sighting postpartum, and of the mom and pup on their first sighting post-weaning, regardless of data type. Always note condition when recording a survival factor.

Condition codes:
M = medium
P = probably pregnant
F = fat
T = thin, includes emaciated
X = data not taken
Codes F and T indicate extreme conditions, seals that are medium-fat, or medium-thin should be coded as medium. **Always code condition explicitly**.

A seal is either identified or not during a sighting. If both the ID No. and Tag No. fields are empty, the seal is unidentified. If either the ID No./Tag No. field is filled, the seal may be identified depending on how the ? columns are filled. Questionable codes blank, 0, or 4 indicate the seal is identified with certainty, whereas codes 1 or 5 indicate uncertainty. If a seal's identity is confirmed by any method, coding for the entire sighting (on the original line and all continuation lines) must ultimately show certainty. For example, if the ID columns indicate the seal is identified with certainty but the Tag columns indicate uncertainty, look up the correct tag number during data editing, enter it, and change the Tag? code from uncertain (1 or 5) to certain (4)).

ID DATA These fields can be used to record either a temporary or permanent ID number. Although the paper form only has one ID field, the database actually has two ID fields. Thus, you can record both a temporary and a permanent ID number on a seal's original line (to do this on the form, split the ID field horizontally and write both numbers on a single line, or expand the original line by sacrificing the subsequent line). Use continuation lines to record two or more temporary numbers. If the seal is identified, it will not be counted twice on census. To link two sightings of an unidentified seal during a survey (i.e. for a cruiser moving ahead of you), assign it a temporary number in a series reserved for unidentified seals, and code a 6 in the temp ? field.

T/P Indicate whether the number in the subsequent field is a temporary or permanent ID number.
T = temporary ID number (or bleach number)
P = permanent ID number

TEMPORARY ID NO. Record the temporary ID number (or bleach number) of seal if known; right justified. This field may be used for any temporary number. Use separate number series for bleach and various types of temporary numbers. If a number is incompletely read, use dashes as place-holders within the number to indicate missing digits (e.g., incompletely read bleach 152 may be coded -52, 1-2, or 15-).

? column:

- 0 = seal is definitely unmarked; can coexist with a temporary number, or with a bleach number if bleach hasn't taken yet or the number has molted off
- 1 = bleach is present but the number is questionable, **and the seal is not identifiable** from other information
- 4 = partially read bleach number completed from other data
- 5 = incompletely read bleach number but partial data are certain, **the seal is not identifiable** from other information
- 6 = temporary number valid for this survey only (for unident. cruisers moving ahead of you on census, etc.). Use a special number series so these numbers are not confused with real temporary ID numbers. Numbers may be reused on the next survey for different seals.
- blank = number is certain and complete if present

PERMANENT ID NO. Record the 4 digit permanent ID number of seal if known (put both the island-specific prefix and next digit in the first box provided).

? column:

- 1 = ID number is questionable, **and the seal is not identifiable** from other information
- blank= ID number is certain and complete if present. A Permanent ID is not visible, and is always completed from other data. For certain ID numbers, **always use ID? = blank, not ID? =4.**

TAG NO. The complete tag number if known; right justified. If a number is incompletely read, use dashes as place-holders within the number to indicate missing digits. Put the alpha prefix of the temple tag (combined with tag ? column code = 5) if you can determine the hole drilling pattern, but can't decipher the number (e.g. A--RT5 for a right tan tag with a 1983 drill pattern). Explain how you came up with the prefix, and draw the hole drill pattern in Notes.

Record all tag sightings explicitly (i.e., both left and right tag numbers) at least once during your stay. During the first weeks of the field camp, note tag condition each time that a tag is sighted. Once the majority of tags have been resighted, observers can carry a list of tags/individuals that haven't been seen, and only note tag condition if these tags/individuals are resighted. Also carry a list of broken or lost tags, and current tag conditions, so that you will be aware, and can record, if a specific tag breaks or is lost, or a tag condition changes during the field season. When a pup is tagged, record the animal handling event on the census data sheet, and record detailed information (such as all tag numbers, all temporary numbers, and the permanent number) on a Tagging/Handling card. If a seal is identified via a tag, it is not necessary to determine and enter its ID number on the census form. The ID number can be determined by computer later.

L/R: Tag position

L = tag on left flipper
R = tag on right flipper
B = tags on both flippers (enter one tag number). This code can be used if the seal has only 2 Temple tags (one on each flipper).

COL: Color code -see the Tag Sample Kit if unsure of the colors

Temple tags	Other tag types
Y = yellow (FFS)	M = metal, Monel
T = tan/brown (Laysan)	C = clear, PIT tag
G = green (Lisianski)	
B = blue (Pearl & Hermes)	
K = silver/gray (Kure)	
R = red (Midway, Necker, Nihoa, Main Islands)	

? column:

0 = seal is definitely not tagged on **either** flipper. To indicate that a seal has lost a tag, code a known missing tag using tag? code 8. If the tag number is unknowable, write the information in Notes.
1 = seal is tagged but the number is questionable, and **the seal is not identifiable** from other information
4 = partially read tag completed from other data
5 = incompletely read tag, but partial data are certain, **the seal is not identifiable** from other information
8 = a specific tag is lost/unreadable. Fill out tag position (L/R) and the tag condition event with codes L or U. Complete the tag number and color from other data before entry.
blank = tag information is certain if present. Partial data (either complete Tag #, position, or color not filled) are OK and will be completed by computer if the seal is identified by ID, Temporary #, or Tag #. The computer will only fill blank fields, so an incomplete Tag # must be completed by hand (use a "4" in the tag ? column).

MOLT Percentage of old pelage lost, optional for pups. However, for weaned pups, record the % molt at time of tagging. Record molt as 100% for at least 1 month post-molt.

blank	=	no molting evident
0-9	=	1 to 99% molted. 0 = molting, but less than 10%; 1 = 10-19%; 2 = 20-29%; ... 9 = 90-99%. The first signs of molt usually occur around the eyes, nose, flippers, and scars. **The first record of a ≥ 2 molt is considered the first day of true molt.**
10	=	100% molted, freshly molted, **required for the first month after molt**. Put both digits of the 10 in the single box provided.

? column:

0 = seal is definitely not molting

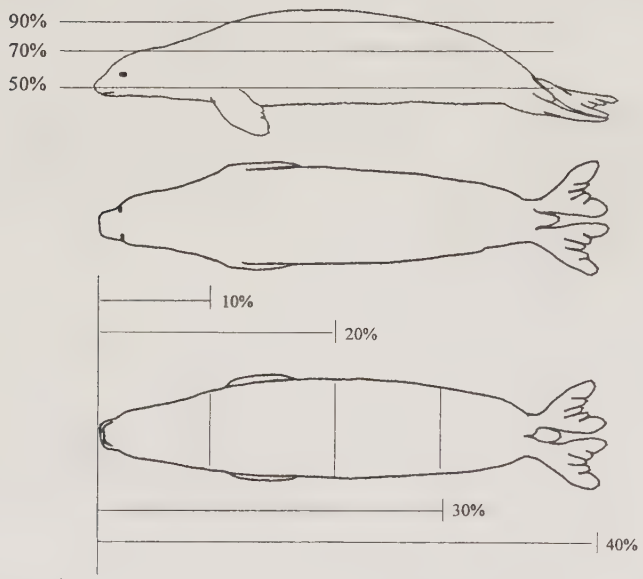
1 = seal is molting, but % molt estimate is questionable. May or may not include an estimate in the molt column

"End of season" editing codes that override molt estimates:

2 = seal in molt

3 = seal pre-molt

4 = seal post-molt



DISTURB The degree to which the seal may have been disturbed by observer. Record disturbance every time a seal is disturbed, regardless of your activity. The only exception is that you do not need to record a disturbance for a seal that you are handling (i.e., tagging, disentangling).

0 = no disturbance, or seal merely raised its head or looked at observer - If column **blank**, 0 is assumed

1 = seal vocalized, gestured, or moved ≤2 body lengths

2 = seal alerted to observer and moved >2 body lengths

3 = seal alerted to observer and fled into water

ASSOCIATION DATA

Behavior data is collected at Laysan and Lisianski Islands because adult male aggression has been more commonly observed at these locations, resulting in injury and death of adult female and immature seals. At Laysan, these data were used to identify 37 males for removal in a successful management action that reduced the adult sex ratio and increased female survival. Data are now used to monitor the long term effects of sex ratio adjustment at Laysan, and assess management options at Lisianski Island.

Record detailed association data at Laysan and Lisianski Islands in 2001. Don't record associations involving turtles. If you wish to indicate that a seal was alone, use the O (this code is alpha, not zero!) behavior code. If you are unable to record association data on a census or behavior patrol at Laysan or Lisianski Island for any reason, indicate this with an X for the behavior code. **Always explicitly record whether the seal is unassociated or association data is not recorded.** Use continuation lines to record more than one association.

An association should either be all blank or have the O, Z, or X behavior only (with no line number or distance), or have a line number, a distance, and some behavior code (other than O or X) all present. Don't code behaviors of an animal after it has been disturbed by the observer (but record the behaviors in Notes).

All associations should be recorded in pairs, i.e., between animals on two different lines. You should fill in the line numbers, distances, and behavior codes for both animals involved in the each association. The association line number should refer directly to the line where the corresponding behavior is coded (i.e. if the corresponding code is on a continuation line, refer to that particular line, not to the original line or a different continuation line).

Active associations

1) interactions are recorded for all seals except behaviors within mother-pup pairs. Only record
   mother-pup interactions during pup exchanges, weanings, or other noteworthy events.
2) must take place within 30 m of observer
3) subjects may be any distance apart

Spatial associations

1) noted as observer comes abreast of the subject
2) individual seals
   - mother-pup pair (N): any distance
   - all others (L): distances ≤10 m away, record two nearest neighbors, can be on opposite sides of a log, etc.

LINE NO. Identity of the other seal in the association. Put its line number here (note line number refers to within same census page only).

DIST. Closest distance during behavior - both associated lines must have the same minimum distance.

0 = body contact
1 = <2 m
2 = 2-5 m
3 = >5 m (>5 m but ≤10 m in the case of L behavior code)

BEHAVIOR Up to four behaviors may be recorded for each association, but L, N, X, and O should not appear together with other behaviors. Behaviors B and M require distance = 0. Behavior J requires distance of 0 or 1. **With the exception of Bites, Chases, Jousts, and Mounts, only record repetitive, sequential behaviors once** (for example, if an animal approaches

three times in a row, code one A). If vocalizations occur, only code V once (whether or not they are sequential). If there is a lot of activity, it is not critical to record all the behaviors. **Focus on the major points**, such as the seals involved, pairings before and after the interaction, the contest winner/loser, and the most intense behaviors (joust, bite, mount, chase, displace). If a behavior is observed that does not have a code, describe it in Notes.

1) individual seal

a) active behavior (directed towards another seal) recorded within 30m of observer

A = approach/investigate/sniff/nudge
B = bite (requires distance 0)
B1 = bite, nip
B2 = bite, draws blood/breaks skin
*C = chase
*C1 = chase, ≤2 body lengths
*C2 = chase, >2 body lengths
*D = seal displaces another (see CONTEST RULES)
F = flee/move away
F1 = flee/move away, ≤2 body lengths
F2 = flee/move away, >2 body lengths move away
*J = joust (requires distance of 0 or 1)
*J1 = joust ≤30 s
*J2 = joust >30 s spar/fight
M = mount/attempted (requires dist. 0) usually A/S4 male
M1 = mount/attempted mount ≤30 s
M2 = mount/attempted mount >30 s
*P = play (typically pup/immature behavior in the water)
R = submissive roll/present ventral
V = vocalize
Z = cruising. A/S4 male only behavior (actual sex may be unknown). Does not require a line number reference to another seal, but may have one)

b) spatial association

N =mother-pup pair (any distance), does not imply actual nursing behavior. This is the only association recorded between mother-pup pairs unless there is an unusual event (i.e., pup switch). If other behaviors are recorded, the N association must be on the original line for each pair member.
L =association by location only (distance ≤10 m apart, for all except mother-pup pairs)

c) additional codes (Laysan and Lisianski 2001)

*L1 = pair assoc. A/S4 male actively defends an adult female or immature of either sex (actual sex may be unknown), or establishes a pair relationship with a female or immature after displacing another male. Code the L1 relationship both before and after the contest if a displacement occurs.
*Q = loser (quitter)
*W = winner
*Y = tie

Note: codes Q, W, and Y are used for A/S4 male-male contests only, although the actual sexes may be unknown (in which case record as though they were known to be males); see the attached **CONTEST RULES**.

* requires a corresponding code on the line of the associated seal

Code	Corresponding code
C, C1, C2	F, F1, or F2
D	F, F1, or F2
J, J1, J2	J, J1, and J2 respectively
P	P
L1	L1
Q	W
W	Q
Y	Y

2) nothing nearby

O = no behavior or association

3) no data

X = no association data recorded on Census or Atoll Count

NOTES--There is room to code 2 different notes. Always use the first column first. Code an H if you have handwritten notes on the observation. Put handwritten notes on the bottom of the census form, labeled by line number. If more than two note codes apply, use continuation lines.

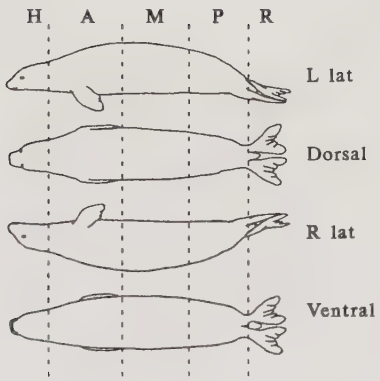
A = artwork (scars drawn) - attach drawing, labeled with date, island, observer, data type, page number, and line number
B = birth, 1st sighting postpartum (mom and pup)
G = seal is green with algae
H = handwritten notes
M = marked, indicate each time a seal is bleached (includes attempts to bleach)
W = weaning, 1st sighting post-weaning (pup)
X = pup exchange, 1st sighting after exchange (mom and pup)
Y = disturbance is to "bystander" seal during non-survey activity such as tagging, bleaching, instrumenting, etc. This includes all "hands on" research, even if the attempt was unsuccessful.

FOR DATA TYPE "T", STATUS OF NON-ACTIVE TAGS (TAGS NOT CURRENTLY ON SEALS):
F = found
R = recovered from seal in hand

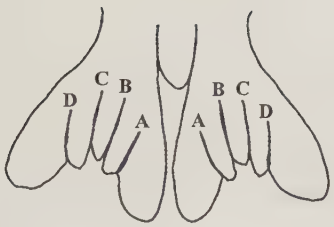
EVENT These columns are used to record a variety of data. The codes used will depend upon the type of event that you wish to record. Left justify your coding:

TYPE	CODES COLUMN	CONTENT
F = survival factor		ONLY RECORD RESIGHT OF A SURVIVAL FACTOR AS AN EVENT IF THERE ARE IMPORTANT CHANGES TO DOCUMENT, SUCH AS A NEW WOUND, HEALING, DEATH, ETC., TRANSCRIBE NOTES TO SURVIVAL FACTOR FORM. FOR TURTLES, USE A DIFFERENT SURVIVAL FACTOR NUMBER SERIES (I.E., BEGIN AT 500), FILL OUT A SURVIVAL FACTOR FORM (OR USE AN ALTERNATE FORMAT IF SPECIFIED BY MTRP), BUT DO NOT ENTER THE DATA INTO THE SEAL SURVIVAL FACTOR DATABASE.
	1-3	Survival Factor number
	4	Factor Type. If seal dead, always record factor type "D" on ORIGINAL LINE. For mobbings/ harassments, always code a census entry with factor type "M" for the victim at the beginning and end of the incident. Otherwise, you only need to record the most appropriate factor type if more than one applies. D = death W = wound E = entanglement V = very thin (emaciated) I = illness/abnormal (includes eye disease) M = mobbing/harassment/post-mobbing aggregation O = other
	5	Participant type (for mobbings/ harassments/post-mobbing aggreg. only) V = victim/subject M = male aggressor
H = handling of wild seal		FOR SEAL CAPTURES OR RELEASES, RECORD DETAILS ON EITHER THE CAPTURE OR RELEASE FORM. OTHERWISE, RECORD DETAILS ON THE TAGGING/HANDLING CARD. HANDLING DOES NOT NECESSARILY INVOLVE RESTRAINT OF SEAL.
	1	Handling type T = tagging (w/ restraint) M = measuring (includes weighing) A = all (both tagging and measuring) R = remote tagging D = disentangle (even if not restrained) I = instrument B = bleeding C = take into captivity F = free from captivity O = other (includes instrument removal and the translocation of seals within an atoll)

TYPE	CODES COLUMN	CONTENT
P = photo		SEAL OR TURTLE PHOTOS ARE THE ONLY PHOTOS CODED ON THE CENSUS FORM. OTHER PHOTOS SHOULD BE RECORDED IN NOTES, AND TRANSFERRED TO THE PHOTO COMMENT FORM.
	1	Type of photo S = slide P = print
	2-3	Roll number (pad with zeros)
	4-5	Frame number (pad with zeros)
	6	Side L = left lateral or flipper R = right lateral or flipper D = dorsal side V = ventral side B = both (used for rear flippers only) X = other, describe in hand-written NOTES
	7	Part H = head A = anterior body (neck and shoulders) M = midbody (behind fore-flippers and before posterior) P = posterior body (behind midbody and before rear flippers) F = foreflipper; write whether dorsal/ventral in comments R = rearflipper; write whether dorsal/ventral in comments O = overall view of a particular side X = other, describe in comments
	8	Purpose I = identification F = survival factor (link with survival factor EVENT using continuation lines) X = other, describe in comments



TYPE	CODES COLUMN	CONTENT
T = tag condition		RECORD TAG CONDITION FOR BOTH SIDES OF EACH TAG AT LEAST ONCE DURING THE SEASON. IF TAG CONDITION IS RECORDED FOR AN INCOMPLETELY READ TAG, COMPLETE THE TAG NUMBER (WITH APPROPRIATE TAG? CODE) PRIOR TO COMPUTER ENTRY.
	1	Web



A-D = from inner (medial) to outer web.
E = ankle
P = posterior
U = unknown

2 Side of tag, the dorsal tag side is on the dorsal flipper surface unless the tag is reversed. For Temple Tags, the dorsal side is the bigger side; for Metal (Monel) tags, the dorsal side is the "male" side. For PIT tags, code the side as B (both).

D = dorsal
V = ventral
B = both
U = unknown

3 Condition, code U (unreadable) if cannot use tag to ID seal (i.e. if broken so number gone). Also code U for a PIT tag if you completely scan for it with a reliable reader but get no reading. If reader is unreliable, put attempt in Notes and only code PIT tag as unreadable after 3 separate attempts. Combine the L or U codes with the tag questionable code of 8. You can combine the tag questionable code of 8 with other condition codes to describe why the tag is unreadable (i.e., worn or broken). Unreadable tags can still be used as partial information to help determine a seal's identity. Code more than one condition using continuation lines.

B = broken
F = faded color
G = good
L = tag lost
N = no/partial resin
O = other
P = pulling out
U = unreadable
V = tag side reversed
W = no. worn /abraded

CONTEST RULES

1. **Male-male contest definition** (must conform to at least one condition below):
   a. Distance between adult males = 0
   b. Either adult male vocalizes (**V**) or performs a **C**, **D**, or **J**
   c. If cruiser approaches to beach position ≥1, regardless of other behaviors

2. **The contest outcome depends upon pair type** (what size/sex seal the adult male is paired with)
   a. For contest rules, size S4 seals are considered to be adults (both sexes), seals size S3 or smaller are considered to be immature
   b. Definition of pair type:
      i. Pair type **#1**: adult male with adult female (**L1**)
      ii. Pair type **#2**: adult male with immature seal of either sex (**L1**)
      iii. Pair type **#3**: *single* adult male not pair type **#1** or **#2**

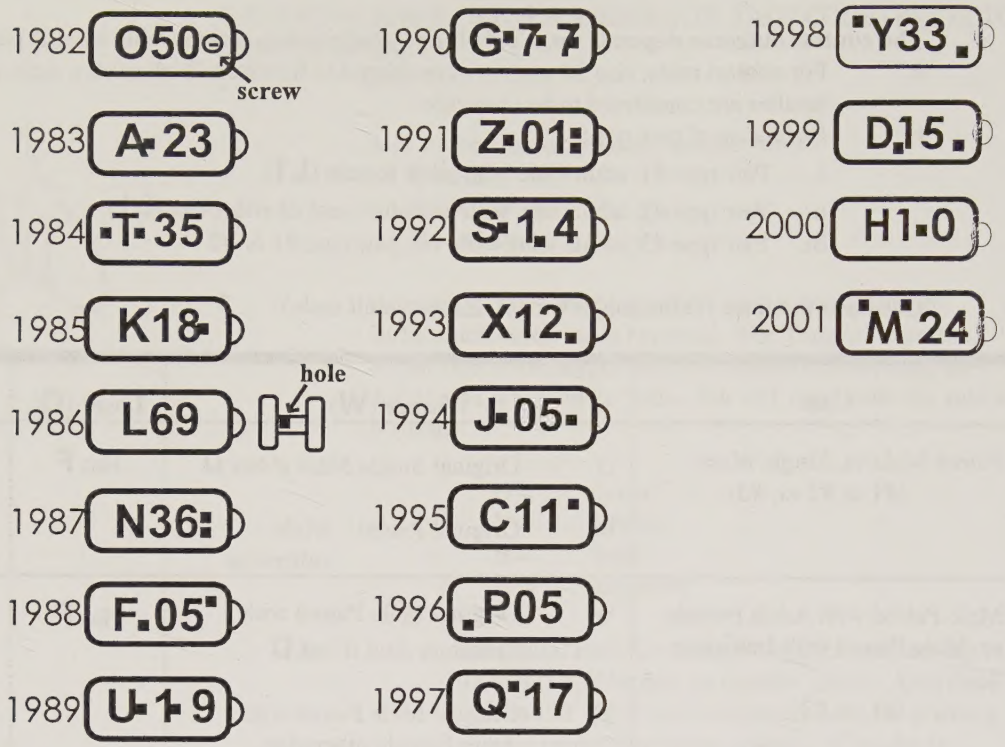
3. **Contest outcomes** (definition of winner or loser adult male):

Case	Winner (**W**)	Loser (**Q**)	Tie (**Y**)
Paired Male *vs.* Single Male: (**#1** or **#2** *vs.* **#3**)	i) Original Single Male if has **D**	Has **F**	No Ties
	ii) Original Paired Male otherwise		No Ties
Male Paired with Adult Female *vs.* Male Paired with Immature Seal: (**#1** *vs.* **#2**)	i) Original Male Paired with Immature Seal if has **D**	Has **F**	No Ties
	ii) Original Male Paired with Adult Female otherwise		No Ties
Paired Male *vs.* Paired Male where both pairs are same type: (**#1** *vs.* **#1** or **#2** *vs.* **#2**)	Has **D**	Has **F**	Tie if no **D**
Single Male *vs.* Single Male: (**#3** *vs.* **#3**)	Has **D** or **C**	Has **F**	Tie if no **D** or **C**

4. **Generalizations:**
   a. **Unequal pair types**
      i. There are no ties
      ii. The male with the **higher pair type (1>2>3) always wins unless he is displaced**
      iii. A seal can win without being aware of the contest. For example, if the "winner" is not aware that the other seal flees, but that seal fled in response to a vocalization, then code the fleeing seal as the loser (Q) and the other seal as the winner (W))

   b. **Equal pair types**
      i. **Males tie unless there is a clear winner/loser**
      ii. To win, a male must chase/displace the other male

HAWAIIAN MONK SEAL TEMPLE TAGS: NUMBERING SCHEME AND HOLE DRILLING PATTERN FOR TAGS APPLIED TO WEANED PUPS



Be sure to code the original tag color, not the color that a tag has faded to. See the Tag Sample Kit.

Original tag color:	**Faded tag may appear:**
Temple Tags:	
Yellow	White, Lt. Yellow
Light Tan (A,T,K,L series @ Laysan)	Gray, Lt. Yellow, White
Dark Tan/Brown (later series @ Laysan)	Red
Dark Forest Green	Dark Blue, Navy
Kelly Green (C, P, and Y cohorts)	--
Blue (light)	--
Red	Orange
Gray (A,T,K,L,N,F,U,G series @ Kure)	Light Tan
Silver Gray (600-900,0,Z and later @ Kure)	Metal

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